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Louisiana Freshwater Sponges: Taxonomy, Ecology and Distribution.

Michael Anthony Poirrier
Louisiana State University and Agricultural & Mechanical College

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Louisiana Fresh-Water Sponges: Taxonomy, Ecology and Distribution

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
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in

The Department of Zoology and Physiology

by
Michael Anthony Poirrier
B.S., Louisiana State University in New Orleans, 1963
M.S., Louisiana State University, 1965
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ABSTRACT

Fresh-water sponges were collected from 184 localities throughout Louisiana with at least one collection from every Parish. A total of 309 collections of 11 species in seven genera was obtained. The following species were found to constitute the spongillid fauna of Louisiana: Spongilla lacustris, Ephydatia fluviatilis, Eunapius fragilis, E. mackayi, Trochospongilla pennsylvanica, T. leidyi, Anheteromeyenia ryderi, A. argyrosperma, Radiospongilla crateriformis, Heteromeyenia baileyi and Dosilia radiospiculata. Their distribution in Louisiana was related to habitat conditions rather than geographic areas or barriers.

Limnological data, including pH, free CO_2, methyl orange alkalinity, phenolphthalein alkalinity, conductivity, chloride concentration and temperature, were obtained from many of the habitats. These data extended the known limits of ecological conditions for most species. Some species were found in slightly brackish water and their relative tolerances to brackish water conditions was investigated.

The siliceous spicules were found to vary with habitat conditions. This variation was extreme in some species, transcending the morphologic criteria used for specific discrimination in the diagnoses of prior workers. The nomenclature and morphology of these species were studied in detail and taxonomic revisions are presented.

I. INTRODUCTION

The family Spongillidae Gray (1867) is not a well defined taxon. According to de Laubenfels (1936) it consists of those sponges occurring in fresh or occasionally in brackish water. Although Penney and Racek (1968) redefined or restricted many of the previous genera of fresh-water sponges and established three new genera, they did not attempt to define the family Spongillidae and regarded this as impossible until further detailed investigations of ill-known genera become available. They excluded from their study the eight genera described as not producing gemmules. All North American species are known to produce gemmules and are typical members of the family Spongillidae.

A summary of the literature concerning the general aspects of fresh-water sponge biology can be found in Pennack (1953). Penney (1960) provided a complete bibliography (1892-1957) and distributional data. The classic reference for North American fresh-water sponges is Potts' monograph (1887). The most important taxonomic reference is Penney and Racek (1968) who revised many genera and species and gave descriptions and taxonomic discussions of North American species.

My study was limited to spongillids which occur within the boundaries of Louisiana. It covered three rather

broad diciplines: distribution, taxonomy and ecology.

The primary objective of distributional studies was to determine what species occurred in Louisiana. Previous records can be found in Annandale (1912) who reported Dosillia radiospiculata and Trochospongilla leidyi from Shreveport, and Moore (1951, 1953a, 1953b) who reported Spongilla lacustris, Ephydatia fluviatilis, Eunapius mackayi, Trochospongilla pennsylvanica, Anheteromeyenia ryderi and Heteromeyenia baileyi from the New Orleans area.

Eshleman (1950) studied the fresh-water sponges of northern Florida. His study is the only comprehensive distributional work on southern fresh-water sponges. Since there are only a few scattered records from the Gulf States, a distributional study of Louisiana sponges would give a better understanding of the fresh-water sponges of the entire area. Scattered distributional records can be found in Hoff (1943) on sponges from Tennessee, Cheatum and Harris (1953) on sponges from Texas, and Penney (1954, 1956) on South Carolina sponges.

The taxonomic studies were on the specific level. There were many problems of nomenclature. Although fresh-water sponge taxonomy was a passing interest for many zoologists there has been no comprehensive revision of North American fresh-water sponges since Potts (1887).

The chief problem in the taxonomy of fresh-water sponges is environmental variation. All species vary to some extent as evidenced by the abundance of synonyms and varieties in the literature. Most earlier workers consid-

ered this variation genetic, but Potts (1887) indicated it might be related to environmental conditions and Jewel (1935) found that the spicules of Trochospongilla pennsylvanica and Spongilla lacustris varied and attributed these variations to differences in the silica and mineral content of the water.

Since fresh-water sponge taxonomy is dependent upon the detailed morphology of variable siliceous spicules, the status of many Louisiana species was uncertain. The goal of my taxonomic studies was to demonstrate that the variation is phenotypic and to describe the different forms of each species and determine the ecological conditions which they were associated. This would lead not only to an understanding of Louisiana species, but to generalizations that would be of value in interpreting morphologic trends in the taxonomy of other species.

Early workers such as Potts (1887) and Stephens (1920) presented general observations concerning fresh-water sponge ecology. Old (1932b) studied the ecology of Michigan species and found that each species had a preferred range of limnological conditions. Jewel (1935) discussed the ecological preferences of Wisconsin species and reported (Jewel, 1939) that calcium in the form of bicarbonate was the most important factor in explaining the habitat selection of Wisconsin species.

Wurtz (1950) summarized the works of Old and Jewel and added additional data from studies in Pennsylvania. Moore (1953b) worked with the ecology of fresh-water sponges

in the New Orleans area and accumulated data which indicated that they could not tolerate water temperatures in excess of 30°C. Cheatum and Harris (1953) studied the seasonal growth of sponges near Dallas, Texas, and found active colonies throughout the year. Penney (1954) gathered additional data for some species in South Carolina.

My work with ecology involved gathering limnological data from habitats where active colonies were found, so that the ecology of species in Louisiana could be compared with the literature on studies in other areas. Particular attention was devoted to the effects of calcium bicarbonate and high temperatures on sponge distribution. Also important was determining the ecology of ecologically unknown species and obtaining data concerning seasonal distribution and gemmule formation in all species. These data were also an important part of the studies of ecological variation.

II. MATERIALS AND METHODS

Although some collections were obtained as early as the fall of 1960, active investigations began in the fall of 1963, with much of the limnological data obtained during the summers of 1964 and 1968. Sponges were collected from 184 localities with at least one collection from every parish in Louisiana. Thousands of colonies were examined and a total of 309 collections of 11 species were obtained from these localities (Table 1).

Habitats were randomly sampled with preference given only to those which were easily accessible. Towards the end of the study, field trips were directed to certain habitat types and waters of specific drainage areas. This was necessary in order to obtain additional collections of rare species and to test habitat generalizations concerning others.

Sponges were collected by wading in shallow waters and examining submerged objects. A garden rake was used to drag objects upon shore from greater depths. The majority of collections were from shoreline area but sometimes a boat was used to collect from large lakes and areas inaccessible by automobile.

Colonies were removed from the substrate with a sharp knife. Large colonies were first dried in the shade while small colonies were placed directly into cardboard

boxes and catalogued.

Flat cardboard boxes were best to store sponges, since they allowed air to circulate and the sponge to dry completely without the fungus growth often associated with other types of containers. They also allowed easy examination of colonies without removing them from the box.

Limnological data which previous workers regarded as important were obtained from habitats where active colonies were present. Water samples were collected with a Kemmerer sampler. Methyl orange alkalinity, phenolphthalein alkalinity, free CO_2, and pH were determined immediately in the field. Chlorides and conductivity were determined later in the laboratory.

A colorimeter manufactured by Racher and Betzold Inc. was used to measure pH. Conductivity was measured with Yellow Springs Instrument Co. model 31 conductivity bridge. Methyl orange alkalinity, phenolphthalein alkalinity, free CO_2, and pH were determined according to the procedures recommended by the American Public Health Association (1960). The mecuric nitrate method was used in determining chlorides.

Free spicules were obtained by treating dried sponges with concentrated nitric acid. A small piece of sponge was removed with forceps and placed on a microscope slide. Concentrated nitric acid was placed upon the sponge. The slide was slowly heated on an electric hot plate until the acid boiled away leaving a residue and spicules. This process was repeated until spicules free from sponge residue

were obtained. Balsam and a cover slip were placed over the dry slide, which was then heated to drive out the xylene. The slide was allowed to cool until the balsam had firmly set. Using this method permanent slides of free spicules of a single gemmule or selected areas of sponge colonies could be rapidly obtained.

In an attempt to obtain more representative samples of spicules from colonies, small portions of sponge were taken from various parts of the colony and placed in a 10 ml test tube. About 2 ml of concentrated nitric acid was added. The test tube was heated until the acid began to boil. After a few minutes the spicules usually separated from the sponge. Water was then added; the mixture was shaken and the spicules allowed to settle. The water and acid were decanted, leaving the spicules at the bottom of the test tube. After rinsing a number of times with 95% alcohol, absolute alcohol was added. The test tube was shaken to suspend the spicules. A few drops of alcohol with suspended spicules were placed upon the slide and ignited. After all the alcohol had burned, only clean spicules remained uniformly distributed on the slide. A cover slip was mounted upon the slide with a drop of balsam.

Slides of whole gemmules were prepared by placing dry gemmules in xylene until the xylene penetrated the granular crust. The gemmules were removed and mounted in balsam.

III. SPECIES ACCOUNTS

Spongilla lacustris (Linnaeus, 1759)

Figures 1,2

1759 Spongia lacustris Linnaeus, Systema Naturae, 10th Ed., p. 1348.

1889 Spongilla wagneri Potts, Trans. Wagner Inst. Phila., 2:7.

1922 Spongilla wagneri, Smith, Trans. Amer. Micros. Soc., 41:406.

1953 Spongilla lacustris, Moore, Proc. Louisiana Acad. Sci., 16:42.

The above synonomy gives the history of Spongilla lacustris in Louisiana. In my master's thesis (Poirrier, 1965) I discussed the taxonomy and ecology of this species in detail. In that study I demonstrated that it is subject to extreme morphological variation in Louisiana, and indicated that Spongilla wagneri Potts, 1889, is one of many ecological variants of S. lacustris.

S. lacustris is the only member of the genus Spongilla Lamarck, 1816, as restricted by Penney and Racek (1968), in Louisiana. It can be distinguished from all other Louisiana fresh-water sponges by its straight, smooth megascleres and small, thin microscleres (Figure 1). The

number of microscleres varied from extreme abundance as in S. wagneri to very few. They ranged in length from 40 to 140 microns.

The gemmules ranged from 350 to 600 microns in diameter. The pneumatic layer with gemmule spicules may be present or absent. The gemmoscleres when present ranged from 50 to 150 microns in length. They were always covered with strong recurved spines and arranged tangentially to radially in the pneumatic layer (Figure 2). The foraminal aperature is a simple pore surrounded by a slight collar.

I reported (Poirrier, 1965) it from seven localities in St. Tammany Parish and from eight localities scattered throughout Lake Pontchartrain from the passes of Lake Maurepas to Chef Menteur Pass and Lake St. Catherine and from two brackish-water bayous in the New Orleans area. I collected it from waters with the following range of physio-chemical conditions.

pH	5.0-8.0
Methyl Orange Alkalinity	5-55 ppm
Chlorinity	0.004-3.20 ppt
Conductivity	30-7.407 micromhos
Temperature	12-37°C

Since 1965, I have collected S. lacustris from nine additional localities scattered throughout Louisiana (Map 1) (Appendix). The only new brackish water record is from Lake Charles in Lake Charles, La. Additional ecological data obtained from some of these habitats are presented in Table 3 and summarized as ranges below.

pH	6.1-7.1
Free CO_2	3.5-13 ppm
Methyl Orange Alkalinity	14-75 ppm

Conductivity	37-2,700 micromhos
Temperature	21-33°C

These additional data only extend the range of methyl orange alkalinity for this species in Louisiana.

Wurtz (1950) summarized the data of earlier workers and reported it from a wide range of ecological conditions as follows.

pH	5.3-9.0
SiO_2	0.0-20.5 ppm
Bound CO_2	0.85-74.8 ppm
Ca	0.16-32.4 ppm
Hardness as $CaCO_3$	60-140 ppm
Conductivity	8-240 micromhos

In Louisiana it was present in localities where the pH measured only 5 and was found in areas much higher in conductivity. It was never found in habitats where gemmules are exposed to drying, and was often green due to symbiotic algae.

Penney and Racek (1968) reported S. wagneri from South Carolina. They reported the excessive numbers of microscleres characteristic of S. wagneri Potts, 1889, but these measured only 49 to 62 microns in length, instead of 125 microns that Potts reported for S. wagneri.

I found (Poirrier, 1965) that the number of microscleres, the size and shape of the microscleres, the shape and texture of the colony, the presence or absence of a layer of gemmoscleres and pneumatic layer around the gemmule all varied in relation to ecological conditions in a restricted geographic area. I discussed the extreme variation reported by various workers throughout the world and demonstrated the futility of using such characteristics as a means of

separating species such as *S. wagneri*.

Ephydatia fluviatilis (Linnaeus, 1759)

Figures 4-15

1759 Spongia fluviatilis Linnaeus, Systema Naturae, 10th ed., p. 1348.

1867 Ephydatia fluviatilis, Gray, Proc. Zool. Soc. London, 1867:492-558.

1881 Meyenia fluviatilis, Carter, Ann. Mag. Nat. Hist., 7:92.

1887 Meyenia robusta Potts, Proc. Acad. Nat. Sci. Phila., 39:225.

1887 Meyenia subdivisa Potts, Proc. Acad. Nat. Sci. Phila., 39:226.

1950 Meyenia subdivisa, Eshleman, Quart. Jour. Fla. Acad. Sci.,12:40.

1953 Meyenia subdivisa, Moore, Trans. Amer. Micr. Soc., 72:26.

1953 Spongilla fragilis, Moore, Trans. Amer. Micr. Soc., 72:25.

1953 Meyenia subdivisa, Moore, Proc. Louisiana Acad. Sci., 16:42.

1953 Meyenia subdivisa, Pennack, Fresh Water Invertebrates of the United States, p. 91.

1953 Meyenia robusta, Pennack, Fresh Water Invertebrates of the United States, p. 93.

1959 Meyenia subdivisa, Jewel, in Edmonson, Fresh-water Biology, p. 304.

1959 Meyenia subdivisa, Jewel, in Edmonson, Fresh-water Biology, p. 306.

1968 Ephydatia robusta, Penney and Racek, U. S. Nat. Mus. Bull., 272:91.

Ephydatia fluviatilis is a cosmopolitan species with a long history of taxonomic confusion. Early descriptions of Linnaeus (1759) and other workers were too general to be of value to modern taxonomy. Their descriptions were not adequate for distinguishing E. fluviatilis from any other undescribed species and they left no reference specimens for determining the correct application of this name.

Bowerbank (1863) was first to give a description in which spicules were employed as a means of taxonomic descrimination. His description did not distinguish between E. fluviatilis and E. muelleri (Lieberkuhn, 1856) and is actually closer to E. muelleri. This confusion persisted even in the works of Carter (1881), whose description, while closer to E. fluviatilis, is insufficient to determine definitely which species he actually described. Later European workers, such as Vejdovsky (1887), were aware of these two species and the difference in the length of the gemmule shaft in relation to the diameter of the rotule which consistently separates them. American workers such as Potts (1887) did not employ the above characters in distinguishing these species until the publication of Potts' key (Ward and Whiple, 1918); when refering to E.

fluviatilis they were usually dealing with E. muelleri which is more common in the northeastern United States. Most workers since that time have agreed as to what they regarded as E. fluviatilis, and the following description from Penney and Racek (1968) in which a neotype is designated, best summarizes their opinions and observations:

> Megascleres slightly curved, rarely straight amphioxea, ranging from fusiform to almost cylindrical, typically entirely smooth; length range 210-400 microns, width 6-19 microns.
>
> Microscleres absent.
>
> Gemmoscleres typically birotulates of one class, with a slender and smooth shaft and terminally with rotules of equal diameter and distinctly flat shape, irregularly and not too deeply incised; malformations frequent in adverse environments, resulting in the projection of the axis through the rotules, or a number of irregular spines on the shaft; length of shaft typically 26-30 microns, diameter of rotules ranging 18 -21 microns; marginal teeth on rotules usually not less than 20.
>
> Gemmules rather abundant scattered throughout skeletal meshwork, spherical, ranging in diameter 350-450 microns; pneumatic layer well developed but comparatively shallow, consisting of minute spherical air spaces; gemmoscleres embedded in this coat in one layer and strictly radially, resting with one rotule on inner gemmular membrane, with the other just reaching to the outer membrane; foramen only very slightly elevated, surrounded by a minute collar never tubular.

This species is illustrated in Plate 7, figures 4 and 5, by Penney and Racek (1968); the plate is reproduced here in Figure 3.

From the beginning of this study it was impossible to distinguish among E. fluviatilis, E. subdivisa (Potts, 1887) and E. robusta (Potts, 1887) in Louisiana. In detailed studies under diverse field and laboratory

conditions the following characters varied in this complex of species: the size of the gemmule and the development of the pneumatic layer; the size, number and arrangement of the gemmoscleres; the number of spines along the gemmosclere shaft and the arrangement of spines in the rotule of the gemmosclere; the presence and degree of development of microspines on the spines on the shaft and those which compose the rotule; the size of the skeletal spicules and the degree of development of microspines.

Variation will be discussed in more detail along with the discussion of habitat conditions and experimental studies. It is such that one character may vary independently of another but with some trends, depending upon habitat conditions at the time of their expression, and showing groups of characters with morphologically different but functionally related variations. These different combinations of variations have led to the description of ecological variants as distinct species in different areas throughout the world.

In North America E. robusta (Potts, 1887) and E. subdivisa (Potts, 1887), which Penney and Racek (1968) considered a junior subjective synonym of E. robusta, certainly fall within what should be regarded as E. fluviatilis. The following description of E. robusta is from Penney and Racek (1968).

> Megascleres slightly curved and moderately stout amphioxea, ranging from cylindrical to subfusiform, armed with inconspicuous spines except at their tips, exceptionally entirely

smooth; length range 230-330 microns, width range 12-17 microns.

Microscleres absent.

Gemmule birotulates of one class, with stout cylindrical shafts, typically with a number of acute and prominent spines, rarely smooth, and terminally with rotules of equal diameter and distinctly flat shape, irregularly incised in a number of lobes and rays; malformations frequent, outer surface of rotule often granulated, spines on shaft forked or subdivided, rotules abnormally developed; length of shaft typically 45-50 microns, diameter of rotules 20-22 microns, width of shaft 6-7 microns.

Gemmules recorded as being scarce in mature sponge; they are spherical, ranging in diameter 360-450 microns, and possess a well-developed granular pneumatic layer, consisting of minute irregular air spaces; gemmoscleres embedded in this coat in a single layer, their distal rotules not penetrating the well-defined outer gemmular membrane; foramen slightly elevated, surrounded by a minute collar, never tubular.

Gemmoscleres of E. robusta are illustrated in Plate 7 of Penney and Racek (1968) figures 11 and 12, reproduced here in Figure 3.

Outside of North America, E. meyeni (Carter, 1849) from India and China, E. ramsayi (Haswell, 1882) from Australia and New Zealand, E. facunda Weltner, 1895, from South America, and E. fortis Weltner, 1895, from the Indo-West Pacific region ranging from Indonesia to the Philipines, Japan and New Hebrides, should be considered doubtful species, since they cannot be distinguished from Louisiana specimens of E. fluviatilis. Criteria for their separation are presented in Plate 7, figures 20, 14 & 15, 16 & 17, and 8 & 9 of Penney and Racek (1968); the plate is reproduced here in Figure 3.

Ephydatia fluviatilis is undoubtedly cosmopolitan as

evidenced by distributional records of many workers from scattered localities throughout the world (Penney, 1960).

Smith (1921), in summarizing the distributional records of fresh-water sponges from North America, indicated E. fluviatilis had been reported from Florida, Illinois and Michigan. He considered records from Ohio, Indiana, Pennsylvania and Wisconsin of Potts and other early workers as questionable, since they were probably based upon E. muelleri, a closely related species common in those areas. Later, Old (1932a) in surveying the fresh-water sponges of Michigan, found E. fluviatilis in only seven localities, representing 2.7% of his total collections; he did not find E. fluviatilis in Delaware (1932c). Jewel (1939) did not find E. fluviatilis in Wisconsin. Neidhoefer (1938) reported E. fluviatilis from Wisconsin. This record is also doubtful since the illustrations and measurements given are closer to E. muelleri than E. fluviatilis. Eshleman (1950) reported E. fluviatilis from Alachua, Lake, Levy, Marion, Sarasota, and Volusia Counties in Florida.

Moore (1953b) first reported E. fluviatilis from Louisiana. He collected it from a drainage ditch four miles north of Crown Point, La., and later from Willswood Pond; both collections were from Jefferson Parish. After a careful study of specimens obtained through the courtesy of Dr. Moore, the record of Spongilla fragilis (Moore, 1953b) was found to be E. fluviatilis growing over a gemmule layer of a previous growth of Spongilla lacustris.

I found E. fluviatilis in 16 localities in 9 parishes in south Louisiana (Map 2) (Appendix). All collections, with the exception of one from Pointe Coupee Parish, were from coastal parishes subject to some brackish water influence. It probably is more common in the coastal marshes than indicated by Map 2, since this survey was limited only to those areas accessible by automobile and small boat. Colonies were abundant in deep marsh canals and ponds with clear but highly colored water and rich growths of alligator weed (Alternanthera philoxeroides) and coontail (Ceratophylum demersum). In other areas it was found in swamps and sloughs, which are dry during the summer months.

E. fluviatilis appears to have an annual life cycle. No colonies were found to be active for more than one year. Its occurrence and relative abundance were subject to seasonal variation. Large colonies were present during the fall, winter, and early spring. Colonies were active and grew throughout the winter months. The most rapid rate of growth occurred in early fall and spring. Larvae, the product of sexual reproduction, were observed being released from sponges collected from City Park in New Orleans and maintained in the laboratory on various occasions from November to May; they are probably produced at other times by actively growing colonies. This was evidenced by the appearance of small sponges less than 5 mm in diameter upon substrate without gemmules. Colonies reached their maximum development in late spring and as the water tempera-

ture approached 30°C gemmule formation began. Within two weeks all active colonies in a locality may become a mass of gemmules in a rapidly disintergrating network of skeletal spicules. By June all that can be found in areas where sponges were formerly abundant is a few gemmules scattered upon firm substrate. No large populations of active, well-developed colonies were found during June and July, although a few small colonies were found in deep water. Active colonies develop from gemmules during August and September or later, depending upon conditions, and the cycle is repeated.

Ephydatia fluviatilis grows readily upon aquatic vegetation, particularly alligator weed and Ceratophylum, but it also grows upon concrete and wood. In shallow sloughs exposed to sunlight, sponges were often green due to the presence of symbiotic algae. In localities such as Lake Pontchartrain and the Kenta Drainage Canal, colonies were exposed to periods of high turbidity due to suspended silt, with Seechi disc readings as low as 0.5 ft, without harmful effects.

Ecological data gathered from 11 Louisiana localities are presented in Table 4 and summarized as ranges below.

pH	6.5-7.7
Free CO_2	3-19 ppm
Methyl Orange Alkalinity	19-200 ppm
Chlorides	0.016-2,600 ppt
Conductivity	350-2,950 micromhos
Temperature	17-33°C

Old (1932b) and Moore (1953b) were the chief contributors to the limnology of this species. Old, working in Michigan, obtained colonies from waters with the following

ranges of conditions.

pH	7.1-8.3
Free CO_2	6.5-9 ppm
Methyl Orange Alkalinity	150-230 ppm
Turbidity	less than 20
Color	40-100
Temperature	51-60°F

Moore (1953b), over a two year period, studied the seasonal occurrence and abundance of E. fluviatilis in a drainage ditch four miles north of Crown Point, Louisiana. The data which he accumulated indicated that temperature is the most important factor in explaining the seasonal occurrence of this species and that the limiting maximum temperature is 30°C. He found active colonies subject to the following range of water conditions.

pH	5.9-6.8
Free CO_2	16-26 ppm
Methyl Orange Alkalinity	43-118 ppm
Chloride	0.515 ppt
Temperature	15-30°C
Dissolved Oxygen	1.00-4.30 ppm
Silica	8-17 ppm
Color	50-120

Free carbon dioxide, pH and temperature were only slightly different, as reported by Moore, than recorded in this study. I found temperature to be important in the formation of gemmules in the spring but not a limiting factor, since sponges were found during August when temperatures as high as 33°C were recorded.

Old reported E. fluviatilis from waters higher in pH (7.1-8.3) and methyl orange alkalinity (150-230 ppm) than encountered in this study.

Most collections from Louisiana were from waters low in methyl orange alkalinity but high in conductivity due

to sodium chloride. The only inland collection was from a roadside slough in Pointe Coupee Parish which measured 200 ppm in methyl orange alkalinity.

E. fluviatilis was present in waters with chloride concentrations as high as 2.6 ppt which would be roughly comparable to salinities of 4.7 ppt based on the formula salinity = 0.3 + 1.805 x chlorinity.

Lentz (1882) reported E. fluviatilis from the Meere Kiel of Germany from brackish water with a specific gravity of 1.0028 equivalent to a salinity of 3.4 ppt. Potts (1889) reported E. fluviatilis from the margin of the Everglades of Florida in an area with an apparent brackish water influence. The occurrence of E. fluviatilis in Lake Pontchartrain and other brackish water areas associated with marine organisms is in accordance with the findings of these authors.

In Louisiana E. fluviatilis is limited to fresh-water areas high in carbonates, the principle salt of most fresh water, and to slightly brackish water which may be low in carbonates but relatively high in sodium chloride. This apparent restriction to these water types is probably the main explanation for its limited distribution in Louisiana and other areas of the United States. This was again shown by the occurrence of this species in the lower Tchefuncte River which receives tidal waters from Lake Pontchartrain. The only collection north of Madisonville was obtained on September 14, 1968; because no gemmules were present the

colonies were carried back to the laboratory for gemmule formation. They were maintained in large plastic trays in about two liters of habitat water for two months. The small pieces of sponges were still active at this time, with some of the tissue reduced and some reduction bodies formed. Gemmules never did form and the sponge disintergrated two weeks later. The pH of the dish at that time was 6.9 and the conductivity 3,900 micromhos, but the bicarbonate alkalinity was only 10 ppm. The Tchefuncte River (Kapusta, 1964) is relatively high in silica but low in bicarbonates. The low concentration of $CaCO_3$ may have been responsible for gemmules not forming, since all other factors were probably present in sufficient amounts for gemmule formation. Ephydatia fluviatilis is not found in this type of habitat, which is very common in Louisiana.

Other factors such as those which cause gemmules to form and germinate at the proper time, food relationships, competition with other species and many others presently unknown, must be taken into consideration to account for its absence from habitats of the Mississippi and Red River floodplains.

Early in this study there appeared to be some relationship between the morphology of the gemmule spicules and the limnology of the habitat. Further analysis of this possible relationship was first attempted through field studies. This quickly proved to be difficult, since they had to be undertaken close to the time of gemmule formation.

Gemmules form within two weeks in late April, May or early June, depending upon the habitat and the prevailing weather conditions. This is also a period of rapidly changing limnological conditions. More than once habitats were visited only to find sponges without gemmules. Habitat analysis was then delayed for two weeks to a month until gemmules formed. When revisited the pool or slough was often found dry or the sponges had formed gemmules and deteriorated. The available habitats were also too scattered for frequent visitation and were without the desired limnological diversity for the study.

Laboratory investigations based on the production of gemmules by sponges maintained in small containers were undertaken instead of field studies. In the laboratory, chemical conditions could be varied and the time of gemmule formation controlled.

It was necessary to determine whether forms regarded as E. robusta (Potts, 1887) in the sense of Penney and Racek (1968) could produce gemmules with spicules typical of E. fluviatilis and whether forms typical of E. fluviatilis could produce gemmules with spicules typical of E. robusta. If so, this would indicate that E. robusta was indeed a variant of E. fluviatilis and that forms present in various localities are not due to inherent genetic differences but merely differences in phenotypic expression due to different environmental conditions.

Sponges for the first experiment of the series were

collected from a slough off the Louisiana and Arkansas Railway tracks 3.5 miles south of Good Hope, La., St. Charles Parish, on February 15, 1965. Gemmules collected from this locality the year before had gemmule spicules typical of E. robusta. One sponge was cut into equal parts about 2 cms in diameter. One part was placed in habitat water which was allowed to evaporate and the other was placed in water from a more typical fresh water habitat, the Amite River in East Baton Rouge Parish. Water was collected near the La. Hwy. 190 bridge on February 17, 1965. Chemical data concerning this stream are available in Kapusta (1964). Specific conductance ranged from 30 to 60 micromhos and the SiO_2 content from 7 to 13 ppm. Calcium carbonate was added to the water because it was low in bicarbonates (10-19 ppm).

Three weeks later slides were made of gemmules which had formed. Those which formed in the evaporating habitat water had gemmules spicules typical of E. robusta. The gemmule spicules were 37 to 58 microns long with shafts 4.6 to 7 microns in diameter. The majority of the spicules had from 6 to 9 spines along the shaft and irregular rotules composed of blunt spines with very coarse microspines, giving them a subdivided appearance. The spines along the shaft were similar to those in the rotule. Some of the rotules were very irregular and more like a burr than a disc (Figure 4). The habitat water at this time had a final pH of 8.5 and a total alkalinity of 400 ppm.

The gemmules which formed in the altered Amite River water had spicules similar to E. fluviatilis. They ranged from 25 to 37 microns in length and had shafts which ranged from 4.1 to 5 microns in diameter. Many of the spicules had no spines along the shaft and those with spines had only 1 or 2 and seldom 3. The spines which formed the rotule and those present along the shaft were delicate and sharply pointed. The rotules were composed of spines arranged in a single plane and fused almost to the tip (Figure 5). This water had a final pH of 7.2 and a total alkalinity of 61 ppm after the gemmules had formed. This one experiment did show the phenotypic nature of this variation and the change from E. robusta to E. fluviatilis.

Additional experiments were set up during the winter and early spring of 1968. Sponges for these experiments were collected from the back lagoons of the New Orleans City Park off Marconi Drive. Gemmules from this habitat and those which formed in the laboratory had spicules which were close to E. fluviatilis. The design of this experiment was to place sponges in waters of many different types and determine what forms would be produced. Colonies were collected on February 17, 1968. Cuttings and small sponges were placed in 8-inch glass stacking dishes with waters of different types, maintained at room temperature, and not disturbed for one month. The following experiments were set up:

(1) Colony in 250 ml of habitat water in which

gemmules had formed before. Reduction bodies formed after two weeks. This seems to indicate that SiO_2 and other materials are removed from the water as gemmules are formed. In this case not enough was left for gemmule formation.

(2) Colony in 250 ml of water from Talisheek Creek, an acid stream low in calcium bicarbonate and other minerals, at La. Hwy. 41 in St. Tammany Parish. The sponge died within two days without forming gemmules.

(3) Colony in 250 ml from Evans Creek, an acid stream low in bicarbonates and other minerals, at La. Hwy. 41 in St. Tammany Parish. The sponge died within two days without forming gemmules.

(4) Colony in 250 ml of habitat water saturated with $CaCO_3$. The sponge died within two days without forming gemmules.

(5) Colony in 250 ml of water from Lake Pontchartrain near the north shore at U. S. Hwy. 11. Gemmules formed and slides were made one month later. Gemmoscleres ranged from 40 to 54 microns in length and had shafts which ranged from 3 to 5 microns in diameter. Some of the gemmules had spicules with 2 to 3 spines and rotules composed of many spines; others had no spines along the shaft and irregular rotules composed of only 3 to 7 spines (Figure 6). This was probably due to the reduction of SiO_2 as the gemmules formed. Those which formed first has robust spicules, while those which formed later were malformed.

(6) Colony in 250 ml of Baton Rouge, La., tap water, aged to remove chlorine. The sponge died within two days

without forming gemmules.

(7) Colony in 250 ml of habitat water. The gemmoscleres ranged from 30 to 40 microns in length and had shafts which were 3 microns in diameter. The rotules were formed from spines arranged in a single plane and fused nearly to the tip. A distinct umbo was present at the end of each shaft. They were usually one or two spines on the shafts but some lacked spines and others had from 3 to 6 spines. They were for the most part similar to E. fluviatilis.

Few conclusions can be drawn from these experiments. The early death of colonies in experiments (2), (3), (4) and (6) probably indicate that the sponges could not tolerate these water conditions. Different results may have been obtained if the pieces of sponge had been left in habitat water for a longer period of adjustment and gradually switched to waters of different types.

Colonies were again collected from City Park in New Orleans, on March 12, 1968, for another series of experiments. Cuttings from large sponges were placed in 8-inch stacking dishes with 500 ml of habitat water. They were held in habitat water at room temperature for two days for adjustment to new conditions and repair of damage. After this time the sponges were exposed to the following experimental conditions.

(1) 25 ml of seawater was added to 500 ml of habitat water each morning and night. The sponge died after a total of 150 ml of seawater was added. The final

conductivity was 32,000 micromhos and the chlorinity was 6.4 ppt. While no gemmules formed, some idea of a maximum salinity tolerance was established.

(2) 100 ml of distilled water was added to the 500 ml of habitat water each morning and night. The sponge began to appear unhealthy as evidenced by a disintergrating normal membrane after 600 ml of distilled water was added. It was dead and covered with fungus six days later.

(3) 100 ml of water from the Mississippi River at Baton Rouge was added to the 500 ml of habitat water each morning and night. After 600 ml of water was added the sponge was transferred to 500 ml of river water. The dish was then set aside until gemmules formed. When checked on April 9, 1968, aquatic oligochaetes of the genus Chaetogaster had multiplied on the surface of the sponge and become so numerous that all that was left of the sponge was balls of cells surrounded by oligochaetes. The abundance of oligochaetes on the surface of the sponge probably interfered with the formation of a dermal membrane and normal functioning of the colony.

(4) 100 ml of aged Baton Rouge, La., tap water was added to the 500 ml of habitat water each morning and night until a total of 600 ml of tap water had been added. The sponge was then transferred to 500 ml of tap water. After two days the dermal membrane disintergrated and reduction bodies began to form. On April 9, 1969, the sponge completely disintergrated. Baton Rouge tap water while con-

sidered soft is usually high in pH (about 8.2) and very high in Na_2CO_3. The reaction of the sponge may be due to the chemistry of the water or to other factors such as heavy metals derived from the plumbing.

(6) One liter of habitat water was placed in a stacking dish and left uncovered to allow the water to evaporate. Sponges produced both gemmules and reduction bodies by April 9, 1968. The gemmule spicules ranged from 35 to 47 microns in length and the shafts were 4 to 5 microns in diameter with 1 to 3 spines along the shafts (Figure 7). Although the salinity increased and the final chloride concentration after the gemmules had formed was 11.3 ppt the gemmoscleres did not differ greatly from the control.

(7) 25 ml of seawater was added daily to the 500 ml of habitat water until a total of 75 ml of seawater was added. Gemmules which formed had spicules with shafts which ranged from 40 to 46 microns in length and from 5 to 6 microns in diameter. They had 7 to 18 large spines along the shaft which ranged from 3.5 to 8 microns in length. On these spine and those which composed the irregular rotules were large microspines which ranged from 1 to 1.5 microns in length (Figure 9).

(8) Control; colony in 500 ml of habitat water. Gemmules formed by April 9, 1968. The spicules were 40 to 47 microns long with shafts ranging from 4 to 5 microns in diameter. The majority of the spicules lacked spines; others had one or two spines. The gemmoscleres were

similar to those of E. fluviatilis (Figure 8).

Coincidental to the above experiments was the formation of gemmules by many sponge colonies which were maintained in a plastic storage tray with about 3 liters of habitat water. The gemmoscleres were 30 to 39 microns long with shafts which were only 2 microns in diameter. The rotules were only 13 to 15 microns in diameter. Only very few of the spicules had a single spine on their shafts. These spicules were very delicate and resembled E. fluviatilis gracilis (Potts, 1887) (Figure 11).

This series of experiments indicated that colonies which develop spicules typical of E. fluviatilis in habitat water can form spicules typical of E. robusta, if chemical conditions are varied, and that colonied derived from the same habitat can produce very reduced spicules.

Sponges were again collected from the New Orleans City Park locality for experiments on April 7, 1968. Gemmules had formed in many of the colonies; those used in the following experiments had gemmules in the basal regions. Gemmoscleres from these gemmules ranged from 30 to 45 microns in length and had shafts which were 5 to 6 microns in diameter. Spines, ranging from 1 to 4 microns in length, were on the shafts of almost all of the spicules. The following experiments were set up using these sponges.

(1) Colony in 250 ml of habitat water with 250 ml of water from the Mississippi River at Baton Rouge added. The next day 100 ml of river water was added in the

morning and 150 ml added that night. Five days later the sponge appeared unhealthy and died. This again indicates the inability of this species to function in water derived from this habitat.

(2) Colony in 500 ml of habitat water with dilute hydrochloric acid added to adjust the pH to 5. The pH would continue to return to near neutrality and would have to be readjusted. In this process the pH was reduced to 4.5 and the sponge died. The experiment was set up again on April 15, 1968. The pH was gradually lowered by adding 1 drop of dilute HCl every two hours. By the next day the pH was down to 5.5. It was readjusted occasionally, but because of field trips and other duties away from the laboratory constant attention was impossible. Gemmules formed by June 24, 1968. At this time the water had a final pH of 6.2. Some of the gemmules at the base of the colony had germinated. The lowered pH was probably responsible for the early disruption of diapause. The gemmules which formed had spicules 25 to 31 microns long with thin shafts only 2 microns in diameter. There were 1 to 7 spines along the shaft and the rotules were only 13 to 16 microns in diameter. In some of the spicules a spine about 7 microns long projected from the end of the shaft. The rotules consisted of an irregular arrangement of spines which were never united at their bases to form a disc (Figure 12).

(3) Colony in 500 ml of habitat water with 300 ml of distilled water added. The next day an additional 100

ml of distilled water was added in the morning and 200 ml added that night. The sponge remainded active and as late as March 17, 1968, larvae were being released. Gemmules had formed by June 22, 1968, and slides were made. The gemmoscleres were very unusual. They were all malformed (Figure 13) with no distinct rotule and very thick shafts. They measured 32 to 45 microns in length and had shafts ranging from 5 to 8.5 microns in diameter. Four to ten spines, ranging from 12 to 25 microns in length, were arranged irregularly along the shaft without the formation of distinct rotules. The shafts were generally free from microspines and ended in a blunt curve. There was no pneumatic layer surrounding the gemmule and the spicules were tangential and not radial in arrangement.

(4) Colony in 500 ml of habitat water with 0.5 grams of $MgSO_4$ added. The gemmule spicules which formed were typical of E. fluviatilis. The length of the shafts ranged from 24 to 33 microns and they were 3.5 to 4 microns in diameter. Only a few of the spicules had a single spine on their shafts (Figures 10, 14).

(5) Colony in 500 ml of habitat water with 2.5 g of NaCl added. The sponge was dead by April 15, 1968. This experiment was set up again with 1 g of NaCl added. Two types of gemmules formed. Some of the gemmules had a thick pneumatic layer with robust spicules with shafts from 29 to 47 microns in length and 5 to 6 microns in thickness. There were 5 to 11 spines along the shafts of each spicule.

The rotules were slightly irregular with microspines. In other gemmules the pneumatic layer was reduced or absent. Fewer gemmoscleres were in these gemmules. Their shafts ranged from 29 to 37 microns in length but were only 2 to 3 microns in diameter. One to three small spines were present along the shaft. These could have been spicules which formed after most of the SiO_2 had been removed from the water, or immature spicules which did not fully develop because of the changes which occurred in the medium (Figure 15).

(6) Colony in 500 ml of habitat water. Gemmules formed on April 10, 1968. They resembled E. fluviatilis with shafts ranging from 25 to 35 microns in length and 4 to 5 microns in diameter. Half of the spicules were without spines. Others had 1 to 3 spines along the shafts.

The above experiments again show that gemmoscleres of different form can develop in sponges from the same locality exposed to different chemical conditions. This demonstrates the impracticality of using such characteristics for the establishment of distinct species.

The detailed investigation of specific factors with which morphological variants are associated and those which directly influence this variation, although very interesting and desirable, was not attempted because it was well beyond the scope of the present work, and would have involved time and equipment not at my disposal during this rather broad study of Louisiana Spongillidae.

Although E. fluviatilis shows considerable variation in Louisiana, it can be separated from all other Louisiana fresh-water sponges by the smooth or microspined megascleres (Figure 14), and the rather large birotulate gemmoscleres of one type. The gemmosclere rotules are composed of fused spines, giving the margins a serrated appearance.

Eunapius fragilis (Leidy, 1851)

Figures 16, 17

1851 Spongilla fragilis Leidy, Proc. Acad. Nat. Sci. Phila., 5:278.

1968 Eunapius fragilis, Penney and Racek, U. S. Nat. Mus. Bull., 272:25.

Penney and Racek (1968) discuss the taxonomy of this species and provide a more complete synonomy. It is cosmopolitan, having been reported from all continents and climates throughout the world (Penney and Racek, 1968). Penney (1960) reports it from 27 states in all areas of the United States. The only published record from Louisiana is based on a misidentification by Moore (1953b), who reported it from Orleans Drainage Canal at Lake Pontchartrain. Since this habitat is brackish, and I have never encountered E. fragilis in brackish water, I examined Dr. Moore's specimens and found these to be E. fluviatilis growing over a layer of gemmules of S. lacustris.

During this survey it was collected from 47 diverse habitats throughout Louisiana (Map 2) (Appendix).

In Louisiana, colonies were usually black encrustations as thick as 6 mm. Seldom were they tan or green due to symbiotic algae. They can be recognized in the field by their conspicuous oscula (Figure 16) and the characteristic arrangement of their gemmules.

The megascleres are smooth straight amphioxea (Figure 17).

more abundant at the tip. They may be straight or slightly curved (Figure 17). Penney and Racek (1968) reported them as ranging from 75 to 140 microns in length and from 2 to 7 microns in width.

The gemmules are of two types. Those at the base of the sponge form a distinct pavement layer attached to the substrate. Others, found throughout the sponge, are arranged in groups of 2 to 5 in a common pneumatic layer consisting of large polygonal air spaces. The gemmoscleres are tangential to the gemmule membrane. The foramen is tubular and reaches to the outside of the thick pneumatic coat. Penney and Racek (1968) give the diameter of the inner gemmular membrane as 180 to 290 microns.

Spicules from Louisiana material fall within the wide range of size variation given by Penney and Racek (1968).

Wurtz (1950) summarized the work of Old (1932) and Jewel (1935, 1937) and gave the following ecological tolerances for E. fragilis.

pH	4.2-9.2
SiO_2	0.3-20.5 ppm
Bound CO_2	2-80.88 ppm
Ca	2.08-45.6 ppm
Hardness as $CaCO_3$	40-200 ppm
Conductivity	16-386 micromhos

Penney (1954) gives ecological data for this species which are within the range given by Wurtz (1950).

Data gathered from 10 Louisiana localities are presented in Table 5 and summarized as ranges below.

pH	6.5-8.7
CO_2	0.0-22 ppm
Methyl Orange Alkalinity	17-230 ppm
Phenolpthalein Alkalinity	5 ppm
Conductivity	37.5-760 micromhos
Temperature	23-34°C

The above data extend the known range for conductivity and bound CO_2 as listed by Wurtz (1950). The methyl orange alkalinity expressed as bound CO_2 would be 101.20 ppm.

The ability of E. fragilis to tolerate waters of diverse conditions accounts for its widespread distribution in Louisiana, the United States and other areas of the world. It was found in lakes, streams, swamps, sloughs, and roadside ditches. It was common in temporary aquatic habitats exposed to seasonal drying. It was in streams north of Lake Pontchrtrain but never extended to areas influenced by brackish water.

It can be found throughout the year in Louisiana, but shows seasonal variation according to habitat. In the majority of localities and especially in seasonal swamps and sloughs, gemmules germinate in the fall and sponges grow throughout the winter and reach their maximum size by late spring. In other habitats, such as streams, gemmules germinate in the spring and sponges grow and produce gemmules in the fall. In habitats where conditions adverse to sponge growth frequently appear, small thin colonies and inactive gemmules may be present at different times during the year.

Eunapius mackayi (Carter, 1885)

Figure 18

1885 Spongilla mackayi Carter, Ann. Mag. Nat. Hist., (5) 15:18-20.

1887 Spongilla igloviformis Potts, Proc. Acad. Nat. Sci. Phila., 39:202.

1950 Spongilla igloviformis, Eshleman, Quart. Journ. Fla. Acad. Sci., 12:38.

1953 Spongilla igloviformis, Moore, Trans. Amer. Micr. Soc., 72:25.

1959 Eunapius mackayi, Jewel, in Edmonson, Fresh-water Biology, p. 301.

1968 Eunapius igloviformis, Penney and Racek, Bull. U. S. Nat. Mus. 272:31.

Penney and Racek (1968) cited this species as Eunapius igloviformis (Potts, 1884). Its inclusion in the genus Eunapius as redefined by these authors shows good taxonomic judgement, since this taxon appears to be natural and very useful. For many reasons I cannot follow their use of the name igloviformis and the citation of Potts, 1884, as the author and date.

Potts (1884) used the name Spongilla iglooiformis in reporting on a series of sponges collected from Nova Scotia by A. H. MacKay. This name has no status in nomenclature, since it was not accompanied by a description, definition or anything that could constitute an indication. If the

Potts (1884) name were used, the original spelling iglooiformis would be proper, not igloviformis Potts (1887). Carter (1885) reported on a collection of sponges obtained from the same locality by MacKay and listed almost all the species that Potts reported a year earlier. He described Spongilla mackayi as new and fulfilled all the criteria of availability for a name. This name then is the oldest available name of this species. Potts was apparently upset by the action of Carter as indicated by the reprinting of his earlier work (Potts, 1884) on the pages immediately following Carter (1885), and stating in a footnote that this was reprinted from a copy sent by him to Carter. Potts (1887), in his monograph, described S. igloviformis as a new species. This description was based upon material from New Jersey. In introducing Carter's description of S. mackayi Potts indicated that this was the same or a nearly related species of S. igloviformis.

When the two species descriptions are compared, no significant differences can be found. In Potts' key to species of sponges in Ward and Whipple (1918) he discussed S. igloviformis and indicated that Carter's species may belong here. Jewel, in revising Potts' key in Ward and Whipple (1959), indicated that the species were synonyms and chose the oldest available name, S. mackayi. Penney and Racek (1968) did not follow Jewel (1959) because she did not give reasons for her actions. They chose to keep these species separate until more material of S. mackayi

becomes available, but did not give any means of distinguishing this species when it is encountered.

These two names exist in the literature today not because of the existence of two separate populations of sponges, but because of the misunderstanding that developed between Carter and Potts, and I follow Jewel (1959) in citing this name.

The following description of S. mackayi is from Carter (1885):

> Sessile, spreading, charged with little subglobular bodies like large statoblasts, about 1-12th inch in diameter. Skeletal spicule acerate, slightly curved, sharp-pointed, more or less thickly spined, averaging 50 by 2½-6000ths inch in its greatest diameters; accompanied abundantly by a minute birotulate flesh-spicule precisely like that of Meyenia Everetti, that is 3 to 4-6000ths inch long, with very thin smooth shaft about four times longer than the diameter of the rotule, which is 1-6000th inch, toothed, with the teeth recurved. Statoblast globular, consisting of a thick chitinous coat filled with the usual germinal matter, from which is very slightly prolonged an everted trumpet-shaped aperture; bearing slight traces externally of microcell-structure and the polygonal tissue; making one of twenty such which are so arranged as to form a subglobular body of the size mentioned; situated around a central cavity with their apertures inwards; the whole supported by statoblast-spicules of various sizes, which, intercrossing each other, form a nest-like globular capsule in which the outer parts of the statoblasts are fixed and covered; apparently (for the specimen is dry) deficient at one point, which leads into the central cavity. Statoblast-spicules acerate, sharp-pointed, like the skeletal spicules, but becoming much shorter and more coarsely spined as they approach the chitinous coats of the statoblasts, where they may be reduced to at least 27-6000ths inch in length, although often increased to 4-6000ths inch in thickness, and their spines, which are very irregular in size and situation, often as long as the spicule is broad.

The following description of *S. igloviformis* is from Potts (1887):

> Sponge light or dark brown, encrusting, thin; surface somewhat corrugated, or smooth, excepting the projecting points of spicules. Lines of skeleton spicules much dispersed, forming no recognizable intertexture; the sarcode in this species being at its maximum in relation to the skeleton spicules, which are seen at their minimum as to numbers.
>
> Gemmules very numerous in compact groups of eight or ten to twenty or more; irregularly disposed upon, but not attached to, the supporting surface. These groups are approximately hemispherical in shape, resting upon a flat subcircular side or base, above which they form a dome-shaped mass suggesting a resemblance to the igloo or hut of an Eskimo. The foraminal apertures of the gemmules composing these groups, contrary to their uniform habit in *S. fragilis*, all open inward, apparently communicating with a central cavity within the mass or group. Each gemmule, as in the last named species, is enveloped in a cellular parenchyma, which also, by short isthmus-like bands, connects it with the adjoining gemmules and finally compacts the members of a group together; but, whereas the parenchymal cells of *S. fragilis* are nearly uniform in size, these are very variable, being large upon the superfices of the gemmule proper and upon the outer surface of the envelope; while the interior cell-structure is with difficulty resolvable under a one-fifth objective. This parenchyma is densely charged with echinating spicules.
>
> Skeleton spicules very few, sub-fusiform, but somewhat enlarged near the terminations, then abruptly pointed or rounded; sparsely microspined; spines short, obtuse.
>
> Gemmule spicules exceedingly numerous, nearly as long as those of the skeleton; sub-fusiform, abruptly pointed, entirely spined. Spines long, acute; perpendicular at the middle of the spicules while those near either end are strongly recurved.
>
> Meas. Skeleton spicules 0.0099 by 0.0004 inches; gemmule spicules 0.00657 by 0.0004 inches.

The measurements from the above descriptions when converted to microns are as follows: In Potts (1887) the skeleton spicules of S. igloviformis were 275 microns in length and 10 microns in diameter, and the gemmule spicules 164 microns in length and 10 microns in diameter. In Carter (1885) the skeletal spicules of S. mackayi were 208 microns in length and 10 microns in diameter, while the gemmule spicules were as short as 113 microns and as much as 17 microns in diameter.

Carter's description of S. mackayi differs from Potts' description of S. igloviformis in that the birotulate flesh spicules similar to those of M. everetti are mentioned in the former. These were undoubtedly introduced into the material examined from neighboring colonies of M. everetti, a possibility mentioned by Carter in a discussion after the species description. Potts (1884) also reported M. everetti as abundant in the same locality.

Potts (1887) copied Carter's (1885) description, but deleted the mention of birotulate flesh spicules. He stated again that he had received and examined specimens of this species from the same locality in 1884.

The differences in size of the skeletal spicules at first appear to be significant. However, these lose significance when compared with the range of variation of specimens collected from Louisiana and Georgia, and similar ranges reported by Penney and Racek (1968).

Megascleres from Louisiana measured 180 to 225 microns

in length and 7 to 11 microns in width. Gemmoscleres measured 80 to 145 microns in length and 6 to 8 microns in width. Gemmules, not including the granular crust, measured 250 to 310 microns in diameter, while the granular crust varied from 70 to 200 microns in thickness.

Spicules from the Georgia collection had megascleres which ranged from 190 to 270 microns in length and 7 to 12 microns in width; the gemmoscleres ranged from 130 to 180 microns in length and 8 to 13 microns in width.

In general the Louisiana specimens agreed with the above descriptions. The colonies consisted of obscure, thin encrustations less than 5 mm thick and were always a dark grey to black color. Skeletal and gemmule spicules typical of this species are presented in Figure 18.

Eunapius mackayi has been reported only from North America. Records have been established by various workers from Nova Scotia and Newfoundland in Canada and from Florida, Louisiana, Massachusetts, Michigan, New Jersey and Wisconsin in the United States (Penney, 1960). The Louisiana record, (Moore, 1953a; 1953b) is based on two collections from seasonal ponds in St. Tammany Parish. I collected this species in Early County, Georgia, 4.2 miles north of the Miller County line on April 9, 1966.

During this survey I found E. mackayi in four additional localities, all in eastern St. Tammany Parish near the sites of previous records. The additional Louisiana records are as follows:

St. Tammany Parish: Evans Creek at La. Hwy 41, July 1, 1964; Bushy Branch Creek at La. Hwy 41, July 2, 1964; Roadside ditch off gravel road 4.5 mi N of US Hwy 190 W of Bayou Liberty, March 17, 1964; Swampy stream at La. Hwy 1088, 1.5 mi S of junction with La. Hwy 36, January 21, 1965.

These Louisiana localities constitute the most western distribution of this species. The limited distribution appears to be due to its ecological preferences which restrict it to the acid areas common in St. Tammany Parish.

The total range of factors for waters from which Jewel (1935) collected this species, as summarized by Wurtz (1950), are as follows.

pH	5.0-6.2
Bound CO_2	0.5-4.5 ppm
Conductivity	7-20 micromhos
SiO_2	0-4.4 ppm
Calcium	0-3.16 ppm

The bound CO_2 reported as methyl orange alkalini .y would be equivalent to 0.61 to 5.49 ppm.

Moore (1953a) found this species exposed to the following physio-chemical conditions.

pH	5.2
Brom-cresol Green Alkalinity	5 ppm

The following limnological data were collected from two localities where active colonies were present:

Evans Creek at La. Hwy 41.

pH	5.4
Free CO_2	26 ppm
Methyl Orange Alkalinity	9.9 ppm

Temperature	23°C

Swampy Stream at Hwy 1088.

pH	5.0
Methyl Orange Alkalinity	5 ppm
Temperature	12°C

Jewel (1935, 1939) characterized this species as limited to acid waters of low bicarbonate alkalinity. Data accumulated by Moore (1953a) fall within the range of conditions presented by Jewel (1935). The collection from Evans Creek was from water higher in methyl orange alkalinity and free CO_2 than reported in previous literature. Three of the four collections were from headwaters of streams subject to flooding and considerable flow, while all reports in the literature were from quiet standing water.

This species appears to be present throughout the year but reaches its maximum development in the ares studied when sloughs and headwaters of streams are filled to their maximum. The ecology of E. mackayi in Louisiana agrees with the general characterization of Jewel (1935, 1939).

Trochospongilla pennsylvanica (Potts, 1882)

Figures 19-28

1856 Spongilla erinaceous Lieberkuhn, Arch. Anat. u. Phys., p. 496.

1882 Tubella pennsylvanica Potts, Proc. Acad. Nat. Sci. Phila., 34:12-14.

1887 Tubella pennsylvanica, Potts, Proc. Acad. Nat. Sci. Phila., 39:252.

1893 Trochospongilla horrida Weltner, Ber. Ges. Naturf. Friende. Berlin, pp 7-13.

1950 Tubella pennsylvanica, Wurtz, Notulae Naturae, 228:6.

1950 Trochospongilla horrida, Wurtz, Notulae Naturae, 228:6.

1953 Trochospongilla pennsylvanica, Moore, Trans. Amer. Micr. Soc., 72:25.

1953 Tubella pennsylvanica, Pennack, Fresh Water Invertebrates of the United States, p. 91.

1953 Trochospongilla horrida, Pennack, Fresh Water Invertebrates of the United States, p. 91.

1959 Tubella pennsylvanica, Jewel, in Edmonson, Fresh-Water Biology, p. 304.

1959 Trochospongilla horrida, Jewel in Edmonson, Fresh-Water Biology, p. 307.

1968 Trochospongilla horrida, Penney and Racek, U. S. Nat. Mus. Bull. 272:135.

1968 Trochospongilla pennsylvanica, Penney and Racek, U. S. Nat. Mus. Bull. 272:137.

Trochospongilla pennsylvanica (Potts, 1882) and Trochospongilla horrida Weltner, 1883 have been regarded as distinct species in the existing literature. During this study, as specimens and data accumulated, it became apparent that what were regarded as two species by previous workers were merely variants of one species.

Trochospongilla pennsylvanica has been reported from scattered localities in eastern North America (Penney, 1960) and India (Annandale, 1911). It was first reported from Louisiana by Moore (1953a). Potts, who described this species, assigned it to the genus Tubella Carter, 1881. Most American workers followed Potts and defended his position (Jewel, 1953; 1959) (Pennack, 1953) (Wurtz, 1950) (Penney, 1960). Other workers, starting with Annandale, (1911) placed this species in the genus Trochospongilla. Penney and Racek (1968) considered the genus Tubella as a synonym of the genus Metania Gray, 1867. They regarded Tubella as an unnatural grouping of species rightfully belonging in three other genera, with T. pennsylvanica in the Genus Trochospongilla Vejdovsky, 1883. I follow the revisionary work of Penney and Racek for reasons of both taxonomy and nomenclature.

The following description of T. pennsylvanica from Penney and Racek (1968):

> Megascleres somewhat slender, feebly curved, sharply pointed amphioxea, rarely amphistrongyla, entirely covered with small, conical, and sharp spines; length range 140-210 microns, width range 8 to 11 microns.

Microscleres absent.

Gemmoscleres minute bitotulates with slender shafts, and terminally with rotules of more or less recurved circular margins, usually of similar shape but invariably of greatly differing diameter; lower rotule always normally developed, upper rotule frequently rudimentary, sometimes irregular; length of shaft 9-11 microns, its thickness about 2 microns; diameter of lower rotule 16-20 microns, of upper 3.5-8.5 microns.

Gemmules rather abundant, confined to lower parts of sponge, sherical, and minute; apparently not encased in a cage of megascleres; diameter ranging 190-390 microns; pneumatic layer granular and comparatively thin, rarely covering the upper rotule of gemmoscleres; gemmoscleres crowed in this layer so their lower rotules distinctly overlap each other; foramen produced into a conical and short porus tube.

Specimens which fit the above description were collected from 19 localities in 11 parishes in all areas of the state (Map 5) (Appendix).

Trochospongilla horrida was first known as Spongilla erinaceus Lieberkuhn, 1856. In 1883 Vejdovsky established the genus Trochospongilla and designated S. erinaceous as the type. T. erinaceus was regarded as invalid by Weltner (1893) because it was occupied as a junior synonym of Spongilla lacustris and T. horrida was established as a replacement name.

Trochospongilla horrida has been reported from France, Rumania, Germany, Poland, Russia, China and from scattered localities in eastern and central United States. Although never previously reported from Louisiana, specimens typical of this species were found at 61 localities in 36 parishes throughout Louisiana (Map 4) (Appendix).

The following description by Penney and Racek (1968) based on existing museum material best characterizes what

has been regarded as T. horrida in the literature:

> Megascleres straight to feebly curved, broadly fusiform, sharply pointed amphioxea, covered with stout and sharp spines in varying patterns; length 175-235 microns, width range 11-15 microns.
>
> Microscleres absent.
>
> Gemmoscleres minute birotulates with a stout, smooth, and short shaft, and terminally with rotules of more or less recurved circular margins and of equal size and shape; length of shaft about 11 microns, its thickness about 4-5 microns; diameter of rotules ranging 9-12 microns.
>
> Gemmules rather abundant, confined to lower parts of sponge, spherical and moderately small; usually encased in capsules of normal megascleras; diameter ranging 475-540 microns; pneumatic layer well developed, but never thicker than the length of gemmoscleres, consisting of rather large air spaces; gemmoscleres embedded in this coat in a single layer; foramen produced into a conical and short porus tube.

As in most fresh-water sponges, the main character used to separate T. pennsylvanica from T. horrida is the difference in morphology of the gemmoscleres. In T. pennsylvanica the rotules are unequal (Figure 19), giving them the appearance of small collar buttons, while in T. horrida the rotules are equal or nearly equal and rotules and shafts thick (Figure 27). Other differences between the descriptions given by Penney and Racek (1968) are the smaller skeletal spicules and gemmules of T. pennsylvanica and the thick pneumatic layer and cage of skeletal spicules around the gemmule in T. horrida but absent in T. pennsylvanica.

Early in this study I considered the two species valid and assigned collections to either of them. Later, intermediates were collected. Gemmoscleres from these intermediate colonies are presented in Figures 19 through 27. Gemmoscleres typical of T. horrida and others typical of

T. pennsylvanica were found in the same sponge and even in the same gemmule; along with forms which were intermediate in morphology between typical gemmosclers. Intermediates specimens were found in 10 localities in 8 parishes scattered in different areas of the state (Map 6) (Appendix).

Even in what was regarded as typical of T. horrida or T. pennsylvanica there was no clear line of separation, with all degrees of variation present in collection from different localities. In the beginning of the study, gemmoscleres with the outer rotule less than one-half the inner rotule were regarded as T. pennsylvanica. While, those forms with thick shafts and the outer rotule greater than one-half the diameter of the inner rotule were regarded as T. horrida. Other characters such as the size of gemmules, the size of the megascleres, the development of the pneumatic layer and cage of skeletal spicules were found to vary and were of no value in distinguishing two species. The development of the pneumatic layer and cage of skeletal spicules was related to the development of the gemmoscleres, but forms with robust gemmoscleres of T. pennsylvanica often had heavy pneumatic layers and some skeletal spicules around the gemmules while other forms with reduced gemmoscleres of T. horrida usually lacked a heavy pneumatic layer and skeletal spicules.

The following specific examples of different forms present at various habitats best illustrates the above observations.

In a collection of what was regarded as T. pennsylvanica, from a slough off La. Hwy. 10 east of the junction with U. S. Hwy. 171, Vernon Parish, the spicules were very reduced. The gemmoscleres shafts were very thin usually less than one micron in thickness. The inner rotules were poorly developed, ranging from 6 to 14 microns in diameter and the outer rotules ranging from 2 to 5 microns in diameter. The gemmules lacked a pneumatic layer and ranged from 240 to 300 microns in diameter. The skeletal spicules ranged from 150 to 180 microns in length and 5 to 7 microns in diameter.

Other forms such as those collected in St. Martin Parish from the Atchafalaya Swamp near Henderson, La. were more robust. The gemmoscleres had inner rotules which ranged from 15 to 17 microns in diameter and outer rotules which ranged from 3 to 7 microns in diameter. The shafts were usually about two microns at their least diameter. The megascleres ranged from 110 to 180 microns in length and 8 to 9 microns in width. The shorter skeletal spicules given in this range were associated with the gemmules forming the cage structure which according to Penney and Racek (1968) is associated with T. horrida. A pneumatic layer which ranged from 15 to 30 microns in thickness and always extended beyond the outer rotule of the gemmule was present. The total diameters of the dried gemmules ranged from 310 to 400 microns.

Variation was also present in forms which were regarded as T. horrida. Sponges collected in St. James Parish from

a canal off La Hwy. 20 just north of the Lafourche Parish line had megascleres which measured 200 to 230 microns in length and 9 to 10 microns in diameter. These forms had very robust gemmoscleres with inner rotules which ranged from 13 to 16 microns and outer rotules which ranged from 11 to 14 microns. The shafts were very thick ranging from 3 to 5 microns.

Collections from Bayou Boeuf, Lafourche Parish, had megascleres which ranged from 170 to 200 microns in length and 8 to 9 microns in diameter. The gemmoscleres were robust with equal rotules which ranged from 11 to 14 microns in diameter and with thick shafts ranging from 2.5 to 3.5 microns in diameter.

Collections from Lake Chicot, Evangeline Parish, had delicate nearly equal gemmosclere rotules with thin shafts of slightly less than two microns. Collections from the Tchefuncte River at La. Hwy. 21 had gemmoscleres with thick rotules and shafts which ranged from 3 to 4.5 microns in diameter. The inner rotules ranged from 13 to 15 microns in diameter, while the outer rotules ranged from 9 to 12 microns with a few reduced to 6 microns. Collections from an old channel of the Comite River, East Feliciana Parish, showed extreme variation in degrees of development of the size of the gemmule and the thickness of the pneumatic layer and associated skeletal spicules. Most gemmules ranged from 190 to 450 microns in diameter, but some gemmules were only 60 microns in diameter. The large gemmules had a pneumatic

layer which was 50 microns thick and robust gemmoscleres, while the smaller gemmules had reduced pneumatic layers and gemmoscleres with thin shafts with slightly unequal rotules.

In populations which were regarded as intermediate, such as collections from a stream east of Goldonna, La., Natchitoches Parish, the megascleres ranged from 160 to 195 microns in length and 6 to 8 microns in diameter. The inner rotules of the gemmoscleres ranged from 9 to 17 microns in diameter while the outer rotules ranged from 5 to 14 microns in diameter. The gemmosclere shafts ranged from 1 to 3 microns in diameter. The collection from a pond south of Port Hudson National Cemetary, East Baton Rouge Parish, had megascleres which ranged from 110 to 180 microns in length and 4 to 6 microns in diameter. The outer rotules of the gemmoscleres ranged from 10 to 15 microns in diameter. The inner rotules ranged from 4 to 10 microns in diameter. The gemmosclere shafts ranged from 1 to 2 microns.

The presence of extreme variation in collections from various localities is neither supprising nor new to science. Potts (1887) amended what he has previously regarded as T. pennsylvanica (Potts, 1882) to include a number of forms which he had regarded as distinct species. His description of 1887 included gemmoscleres which ranged from what is now regarded as T. pennsylvanica to forms which could be T. horrida. This synonomy was probably not recognized by Potts, since T. horrida was known only from Europe then and

the specimens described had a very thick pneumatic layer, which Potts regarded as sufficient for specific separation. The illustrations of Potts (1887) Plate 12, Figures 1, 2, and 3, which show intermediates, have apparently been ignored by later workers. Potts obtained this serial collection from eastern Pennsylvania. The gemmoscleres with reduced outer rotules were obtained from areas of high altitudes such as Bear Lake with an elevation of 1,800 feet and more robust specimens were obtained from localities at lower altitudes. He described forms as robust as those found in T. leidyi from the tide water of the Schuylkill River. The gemmoscleres of T. leidyi are similar to the robust gemmoscleres of T. horrida.

Jewel (1935) encountered variations in T. pennsylvanica in Wisconsin, but non had expanded outer rotules and thick shafts typical of T. horrida. She forms with very poorly developed skeletal and gemmule spicules to forms considered typical of robust T. pennsylvanica. She related this variation to differences in the silica and mineral content of the respective habitats and mentioned that the variation observed by Potts was probably due to increased mineralization of habitats in the lower portions of the drainage systems.

Wurtz (1950) summarized the known range of limnological conditions for T. pennsylvanica in the prior literature. These are as follows.

pH	4.2-8.5
SiO_2	0.0-10.75 ppm

Bound Carbon dicxide	0.5-21 ppm
Calcium	0.3-11.8 ppm
Hardness as $CaCO_3$	40-80 ppm
Conductivity	7-75 micromhos

Penney (1954) gathered data from one locality which falls within the range given above. Ecological data collected from seven localities in Louisiana during this study are presented in Table 6 and summarized as ranges below.

pH	5.4-6.9
Free CO_2	6-26 ppm
Methyl Orange Alkalinity	9.9-85 ppm
Conductivity	39.5-163 micromhos
Water Temperature	23-31°C

The high values for conductivity and methyl orange alkalinity are from one collection from the Atchafalaya near Henderson, La., St. Martin Parish. A methyl orange alkalinity of 85 would be roughly equivalent to a bound CO_2 concentration of 39.40. This value and the conductivity of 163 micromhos are higher than reported by Wurtz (1950). T. pennsylvanica was found in three lakes, but was more common in swamps, roadside ditches, sloughs and small streams in the headwaters of drainage systems.

Little is known concerning the ecology of T. horrida, since it was not encountered by Old in Michigan nor Jewel in Wisconsin. Wurtz (1950) gave the following data concerning this species from one locality in Pennsylvania.

pH	7.8
SiO_2	9.25 ppm
Bound CO_2	68.57 ppm
Ca	45.6 ppm
Hardness as $CaCO_3$	156 ppm
Conductivity	322 micromhos

Penney (1954) collected T. horrida from two localities in South Carolina and gathered the following ecological data.

pH	6.5-7.1
Bound CO_2	6.48-12.7 ppm
SiO_2	7.5-7.8 ppm
Ca	4.1-5.8 ppm

Data collected from 22 localities in Louisiana, where active colonies of T. horrida were present, are presented in Table 7 and summarized as ranges below.

pH	5.5-8.7
Free CO_2	0.0-15 ppm
Methyl Orange Alkalinity	7.0-185 ppm
Phenolphthalein Alkalinity	0.0-15 ppm
Conductivity	41-220 micromhos
Water Temperature	25-34°C

Data from Louisiana extend the limit of those factors measured except conductivity which Wurtz (1950) reported as 322. T. horrida was certainly collected from waters higher in conductivity than indicated above since it was often found in water with a very slight brackish influence such as the Kenta Drainage Canal, Jefferson Parish, and the tide waters of streams north of Lake Pontchartrain. It was common in large streams, lakes and roadside sloughs.

Ecological data from three localities where intermediates were collected are presented in Table 8 and summarized as ranges below.

pH	6.4-6.6
Free CO_2	6-8 ppm
Methyl Orange Alkalinity	16-29 ppm
Conductivity	41-170 ppm
Water Temperature	26-29°C

These data, except for high conductivities, are closer

to those of T. pennsylvanica than T. horrida. Although data were collected for ecological tolerances and not for morphological analysis, morphological trends related to habitat conditions are apparent. The correlation between chemical conditions and spicule morphology was not always consistent because limnological conditions are subject to seasonal variation. The spicules which were present in a given habitat may have formed under conditions different from those that were measured at the time the habitat was sampled.

Trochospongilla pennsylvanica was usually found in waters low in pH, high in free CO_2, low in alkalinity and conductivity. While T. horrida was found in waters high in pH, low in free CO_2 and high in alkalinity and other minerals.

The existence of variants which had been known as distinct species in related to the ecological conditions of a habitat and are non-genetic in nature.

Laboratory studies were undertaken to determine if variation was non-genetic and to gain information as to what factors were responsible for the variation. These studies were dependent upon the formation of gemmules by sponges maintained in the laboratory. Colonies about 2 cm in diameter were placed in one-pint plastic containers with modified habitat water or water from a different habitat.

The following series of experiments involved colonies which formed gemmules typical of T. pennsylvanica in the Atchafalaya Swamp near Henderson, La. Colonies without

gemmules were collected on June 21, 1968, and the following experiments were set up.

(1) Control: Colony in 500 ml of habitat water covered to prevent evaporation. The gemmoscleres which formed were more robust than those from the natural habitat. The inner rotules ranged from 12 to 17 microns in diameter, while the majority of the outer rotules were typical of T. pennsylvanica some were enlarged ranging from 8 to 12 microns in diameter. Some of the shafts were also thicker, ranging from 2 to 3 microns in diameter. The final pH of medium was 7.3 and the methyl orange alkalinity 125 ppm. These values were higher than those measured in the natural habitat. This was probably due to the escape of free CO_2.

(2) Colony in 250 ml habitat water with a total of 10 ml seawater gradually added. The sponge died and disintergrated without forming gemmules.

(3) Colony in 250 ml habitat water with a total of 25 ml seawater gradually added. The colony died and disintergrated without forming gemmules.

(4) Colony in 250 ml habitat water with 75 ml of water from Lake Pontchartrain gradually added. The sponge died and disintergrated within one week without forming gemmules. The final conductivity of the medium was 2,700 micromhos and chloride concentration of 0.875 ppt.

(5) Colony in 250 ml of habitat water with 25 ml Lake Pontchartrain water added. The colony died and disintergrated without forming gemmules.

(6) Colony in 250 ml habitat water with $CaCO_3$ added to give a final methyl orange alkalinity of 170 ppm. The gemmules that formed had many gemmoscleres with enlarged outer rotules which ranged up to 10 microns, while the inner rotules ranged from 13 to 16 microns. Others had reduced outer rotules typical of T. pennsylvanica.

(7) Colony in 500 ml habitat water allowed to evaporate. Many of the gemmoscleres which formed had expanded outer rotules which ranged up to 14 microns. The inner rotules were 12 to 15 microns in diameter and the shafts about 2 microns in diameter.

The above series of experiments indicated the outer rotule of T. pennsylvanica is subject to non-genetic variation due to environmental conditions. The gemmoscleres which formed with equal or near equal birotulates were not typical of T. horrida because the rotules and shafts were thin and resembled intermediates in figure 22. These were, however, closer to T. horrida than T. pennsylvanica. The gemmoscleres which changed most were those in which the mineral content and alkalinity increased by the addition of $CaCO_3$ or through evaporation.

Sponges collected from Bayou Teche near Evangeline State Park, St. Martin Parish, on June 22, 1968, were used in the second series of experiments. The gemmoscleres which were obtained from this habitat were typical of T. horrida. The following experiments were set up:

(1) Control: Colony in 250 ml habitat water. In the

gemmules which formed the majority of the gemmoscleres were like T. horrida but with slightly reduced shafts and rotules, while some of the gemmules had gemmoscleres which were typical of T. pennsylvanica. The inner rotules were 14 to 16 microns in diameter and the outer rotules 6 to 12 microns. They had shafts from 2 to 4 microns in diameter.

(2) Colony in 250 ml of water collected from the Atchafalaya Swamp, near Henderson, La., St. Martin Parish. The results were the same as in the control except that more of the gemmoscleres in some gemmules resembled T. pennsylvanica.

In the third series of experiments sponges collected from an old channel of the Comite River off La. Hwy. 67 in E. Feliciana Parish on August 25, 1968, were used. The gemmoscleres in this habitat were typical of T. horrida.

(1) Colony in 300 ml habitat water. The gemmoscleres which formed had thin reduced outer shafts and rotules and resembled T. horrida while others appeared as robust T. pennsylvanica.

(2) Colony in 200 ml habitat water with 300 ml water added in 50 ml portions each morning and night for three days. The colony decreased in size and the tissue became reduced. Only one gemmule formed after three weeks. Gemmoscleres which formed had thin shafts and thin rotules. The outer rotules were slightly reduced.

(3) Same as experiment 2 except the sponge died and disintergrated four days after the last water was added.

(4) Same as experiment 3.

Colonies used in the next series of experiments were collected from a pond at La. Hwy. 10, East Feliciana Parish, on August 25, 1968. Gemmules collected from this habitat were typical of T. pennsylvanica. The following experiments were set up:

(1) Control: Colony in 250 ml of habitat water. Gemmoscleres which formed were slightly more robust than those collected from the natural habitat.

(2) Colony in 250 ml of habitat water with 10 ml of Lake Pontchartrain water added. Many gemmules formed within two weeks. The gemmosclere were similar to those produced in the control. The gemmules were large, ranging from 340 to 390 microns.

(3) Same as experiment 2 with same results.

(4) Colony in 250 ml habitat water with 10 ml of a 3.5 gm/liter solution of $Na_2SiO_3.9\ H_2O$ solution added. The colony died and disintergrated within four days.

(5) Colony in 250 ml of habitat water with 5 ml of the sodium silicate solution used in experiment 4. Many gemmules formed. In some gemmoscleres the rotules were equal but thin and with thin shafts.

(6) Colony in 200 ml habitat water with 10 ml Lake Pontchartrain water added and allowed to evaporate down. The gemmoscleres produced were very robust T. pennsylvanica with enlarged outer rotules.

(7) Colony in 500 ml habitat water allowed to evapor-

ate down. Many gemmoscleres with enlarged outer rotules were produced in gemmules. In some of the gemmoscleres the rotules were equal.

The last series of experiments involved sponges collected from Abita Creek at La. Hwy. 435, St. Tammany Parish, on September 22, 1968. Gemmules collected from this habitat had gemmoscleres which were typical of T. horrida.

(1) Colony in 200 ml habitat water with 125 ml distilled water added. The majority of the gemmoscleres were typical of T. horrida although some had unequal rotules and thin shafts.

(2) Colony in water collected from a slough off La. Hwy. 1, south of Powhatan, La., Natchitoches Parish, in which T. horrida had previously formed gemmules. The gemmoscleres which formed were smaller than those from the natural habitat. They had thin shafts which ranged from 1.3 to 2 microns while the inner rotules from 10 to 13 microns. They resembled the gemmoscleres with equal rotules which formed from typical T. pennsylvanica in previous experiments.

(3) Colony in 200 ml habitat water in which 200 ml distilled water and peat had been added to reduce the pH. The majority of the gemmoscleres which formed were typical of T. horrida while in a few gemmules there were spicules typical of T. pennsylvanica.

(4) Colony in 200 ml of water from the Bogue Chitto

River at La. Hwy. 348, Washington Parish, in which gemmules of T. horrida had already formed. The gemmoscleres were small. The inner rotules ranged from 9 to 12 microns, while the outer rotules ranged from 7 to 10 microns. The shafts were thin ranging from 1 to 2 microns.

Experimental studies could not be continued since this species forms gemmules in the fall and active colonies without gemmules could not be collected again until early spring.

While colonies from habitats with gemmules typical of one extreme did not produce all gemmoscleres typical of the other extreme in the laboratory, intermediate gemmoscleres and a few gemmoscleres typical of the other extreme were produced. These experimental studies were limited in extent by seasonal availability of mature colonies without gemmules and should be regarded as preliminary rather than exhaustive in nature. They do, however, support the theory that the variation and intermediates observed in field studies are not due to genetic differences between two species, but due to differences in habitat conditions. This then leads to the conclusion that only one species, T. pennsylvanica, is represented by this morphological diversity. It can be separated from all other Louisiana freshwater sponges by the heavily spined megascleres (Figure 28) and small birotulate with smooth rotules (Figures 19-27).

Trochospongilla leidyi (Bowerbank, 1863)

Figures 29, 30

1863 Spongilla leidii Bowerbank, Proc. Zool. Soc. London, p. 445.

1863 Spongilla leidyi Bowerbank, Proc. Zool. Soc. London, Pl. XXXVIII.

1932 Trochospongilla leidyi, Gee, Peking Nat. Hist. Bull., 6:16.

1950 Trochospongilla leidii, Wurtz, Notulae Naturae, 228:5.

1968 Trochospongilla leidii, Penney and Racek, U. S. Nat. Mus. Bull., 272:138.

1968 Trochospongilla leidyi, Penney and Racek, U. S. Nat. Mus. Bull., 272: Plate 12.

The name of this sponge has two spellings in the original publication (Bowerbank, 1863). Trochospongilla leidii is used in the text while T. leidyi is used in the illustration of the spicules. The spelling T. leidyi has been used by the majority of workers, with the exception of Carter (1881), Wurtz (1950) and Penney and Racek (1968). Wurtz (1950) stated that T. leidii is correct according to the rules of nomenclature, but probably he was not aware of two spellings in the original publication. Penney and Racek (1968) used the name leidii on page 138 but leidyi on Plate 12 of their publication. Article 32b of the International Code of Zoological Nomenclature, regarding multiple original spellings, states that the name adopted by the first revisor

is to be accepted as the correct original spelling. Gee (1932), in "Genus of Freshwater Sponges", cites T. leidii (Bowerbank, 1863) as a synonym of T. leidyi (Bowerbank, 1863). I regard Gee (1932) as the first revisor and accept T. leidyi as the correct original spelling. The spelling leidyi is more desirable, since it was given in honor of Joseph Leidy and is established and has been widely used.

Trochospongilla leidyi is known only from the United States, where it has been reported by various workers from Arkansas, Florida, Illinois, Kentucky, Louisiana, New Jersey, Ohio, Pennsylvania, Texas and West Virginia (Penney, 1960). Annandale (1912) first reported T. leidyi from Louisiana.

During this study I collected it from 31 localities in 20 parishes throughout Louisiana (Map 7) (Appendix). It is easy to recognize because of the characteristic growth form of mature colonies. They consist of flat encrustations which are usually only a few mm in maximum thickness, but under optimum conditions are limited in extent only by the size of the substrate. Their color is usually dark grey and texture very compact and fine with the subdermal canals affanged in a characteristic pattern (Figure 29).

The skeletal spicules are stout smooth amphioxea, while the gemmoscleres are small birotulates (Figure 30). Each gemmule is surrounded by a cage of megascleres, except

near the foramen which projects as a short conical tube.

Trochospongilla leidyi showed little variation in the morphology of the spicules, although there was some variation in the length and diameter of the megascleres from different localities. In some localities such as Bayou Queque de Tortue, Acadia Parish, the megascleres ranged from 120 to 145 microns in length and 12 to 15 microns in thickness. In other localities, such as a drainage canal west of Hwy. 90, Lafourche Parish, the megascleres ranged from 130 to 170 microns in length and 8 to 10 microns in thickness.

The megascleres from some localities had an irregular surface which, under 970 magnification, had a coarse granular appearance. This type of megasclere was more often associated with the cage of megascleres around the gemmule. The gemmoscleres ranged from 11 to 12 microns in length. The diameter of the shafts ranged from 5 to 6 microns and diameter of the rotules ranged from 15 to 16 microns.

Only in one locality were the gemmoscleres malformed. Gemmules collected from a barrow pit north of the Bonnet Carre Spillway, St. Charles Parish, had thin shafts ranging from 1.5 to 2 microns and thin reduced rotules. The gemmules ranged from 370 to 520 microns in total diameter.

Ecological data gathered from 20 localities are presented in Table 9 and summarized as ranges below.

pH	6.8-8.7
Free CO_2	0.0-18 ppm
Phenolpthalein Alkalinity	15 ppm
Methyl Orange Alkalinity	24-185 ppm

Conductivity	80-3,000 micromhos
Chlorinity	0.575-1,100 ppt
Temperature	26-34°C

Trochospongilla leidyi was found in alkaline waters high in bicarbonate alkalinity or relatively high in conductivity due to NaCl. It was abundant in areas which receive slightly brackish tidewaters, such as the lower portions of streams which boarder on Lake Pontchartrain. It was found in brackish water areas such as the north shore of Lake Pontchartrain and the passes of Lake Maurepas where salinities certainly reach 2 ppt.

Active colonies were found only during the summer months, and only gemmules collected during the winter. Small colonies and gemmules were present during early spring.

Small thin colonies were often collected from water that was very turbid due to suspended silt. It was never green from symbiotic algae and was never found in temporary waters where gemmules are subject to seasonal drying.

Anheteromeyenia ryderi (Potts, 1882)

Figures 31-35

1882 Heteromeyenia ryderi Potts, Proc. Acad. Nat. Sci. Phila., 34:13.

1931 Heteromeyenia conigera Old, Trans. Amer. Micr. Soc., 50:298.

1953 Heteromeyenia ryderi, Moore, Trans. Amer. Micr. Soc., 72:26.

1968 Anheteromeyenia ryderi, Penney and Racek, Bull., U. S. Nat. Mus., 272:117.

Gee (1932) reported A. ryderi from the United States, Sable Island, Ireland, Scotland, and Canada. Penney (1960) reported it from 17 states in the central and eastern United States. It was first reported from Louisiana by Moore (1953). During the present study it was found in 32 localities in 20 parishes throughout Louisiana (Map 8) (Appendix).

Colonies have a variable growth form and mature specimens are difficult to identify under field conditions. They ranged from small compact growths of only a few mm in diameter and thickness to large forms which were several cm thick and as large as 10 cm in diameter.

The genus Anheteromeyenia in the sense of Penney and Racek (1968) includes fresh-water sponges without microscleres and with gemmoscleres of two distinct classes. In A. ryderi the shafts of the longer class of gemmoscleres

are spined and the rotules are composed of a number of large recurved spines which form hooks (Figure 31). The short class of gemmoscleres have shafts with only a few spines and the rotules are flat to slightly umbonate (Figure 31). These rotules have many small teeth at their margins, giving them a crenulate appearance. The megascleres are fusiform amphioxea which are covered with large spines except at their tips.

Extreme variation was present in spicules from different habitats. Those from small acid streams such as Abita River and Evans Creek, St. Tammany Parish, had short robust spicules. Collections from the Abita River at La. Hwy. 435 had megascleres from 190 to 240 microns in length; short gemmoscleres from 20 to 28 microns in length and long gemmoscleres from 37 to 46 microns. Megascleres from Evans Creek ranged from 280 to 330 microns in length; short gemmoscleres ranged from 25 to 33 microns and large gemmoscleres ranged from 45 to 60 microns (Figure 32).

In other habitats such as Carson Lake, Beauregard Parish, the megascleres and gemmoscleres were extremely thin and lacked well developed spines along the shafts. The megascleres ranged from 205 to 283 microns in length, while the short class of gemmoscleres ranged from 35 to 45 microns and the long class ranged from 50 to 60 microns (Figure 33). Spicules such as these were found in acid standing waters low in bicarbonates and other minerals.

Spicules were larger in collections from temporary sloughs and swamps along the Mississippi River floodplain

which were high in bicarbonates and other minerals. Megascleres ranged from 250 to 360 microns in length while the short gemmoscleres ranged from 26 to 46 microns in length, and the long class were 50 to 70 microns long. The number of large gemmoscleres in gemmules was greatly reduced in many of these habitats. The shafts of both classes of gemmoscleres had many spines which were often microspined and subdivided. In some forms the rotules were irregular and it was hard to distinguish two classes of birotulates. Spicules from some of these collections resembled robust forms of E. fluviatilis (Figure 34).

Potts (1887) reported A. ryderi as a highly variable species and Penney (1956) found differences in the average size of gemmules, gemmoscleres and megascleres in colonies from five localities in South Carolina. These variations appear to be related to habitat conditions with some variation among the gemmoscleres in the same colony and a continual series of variants between extreme forms.

Penney and Racek (1968) stated that the gemmoscleres of A. ryderi are hardly identical in any two specimens and after reviewing the holotype of H. conigera Old (1931) they indicated that it is probably nothing more than a malformed specimen of A. ryderi.

Spicules typical of H. conigera were produced in the laboratory. Colonies without gemmules were collected from the Pushepatapa Creek at La. Hwy. 436, Washington Parish. These small colonies were carried back to the laboratory

and placed in plastic containers filled with habitat water until gemmules formed for identification. Most of the gemmules which formed were typical of H. conigera, while others approached A. ryderi. The production of gemmoscleres similar to H. conigera was probably due to the unusual condition of the stream at the time of the collection. The specimens were gathered after heavy rains. The habitat water in which the colonies were placed was probably lower in silica and other minerals due to the abundance of rain water. The gemmoscleres which formed had reduced shafts, giving the rotules a conical appearance typical of H. conigera (Figure 35). H. conigera is an ecological variant of A. ryderi.

Active colonies of A. ryderi were found throughout the year, but they were most abundant during winter and early spring. Gemmules were usually produced in spring as water temperatures approached 30°C.

Wurtz (1950), who summarized the work of Old (1932) and Jewel (1935, 1939), reported A. ryderi active under the following range of ecological conditions.

pH	4.2-8.5
SiO_2	3.8-7.75 ppm
Bound CO_2	17-54.15 ppm
Ca	1.2-22 ppm
Hardness as $CaCO_3$	40-80 ppm
Conductivity	90-205 micromhos

Moore (1953b) and Penney (1954) gathered additional ecological data, which, with the exception of bound CO_2, falls within the range given by Wurtz above. Penney (1954) reported A. ryderi from a habitat with a bound CO_2 concen-

tration of 4.4 ppm and Moore (1953b) found it in a locality with a brom-cresol green alkalinity of 6 ppm equivalent to a bound CO_2 concentration of 2.64 ppm.

Ecological data collected from nine Louisiana localities during this study are presented in Table 10 and summarized as ranges below.

pH	5.2-7.1
Free CO_2	4-22 ppm
Methyl Orange Alkalinity	4-128 ppm
Conductivity	37-170 micromhos
Temperature	20-32°C

The values for methyl orange alkalinity and conductivity presented above are lower than values reported by other workers. Other factors fall within the range of those recorded by Wurtz (1950). It was common in areas of acid drainage in the Florida Parishes and southwest Louisiana, but was also found in isolated swamps and sloughs along the Mississippi River floodplain and was the mose common species in habitats subject to seasonal drying. Jewel described A. ryderi as being independent of calcium content. It was not common in areas high in bicarbonates and was never found in brackish waters. Its ecology in Louisiana generally agrees with that of other workers.

Anheteromeyenia argyrosperma (Potts, 1880)

Figures 36, 37

1880 Spongilla argyrosperma Potts, Proc. Acad. Nat. Sci. Phila., 32:356-357.

1881 Heteromeyenia argyrosperma, Potts, Proc. Acad. Nat. Sci. Phila., 33:149-150.

1968 Anheteromeyenia argyrosperma, Penney and Racek, U. S. Nat. Mus. Bull., 272:116.

Anheteromeyenia argyrosperma is known only from North America. It has been reported from Delaware, Florida, Illinois, Indiana, Michigan, New Hampshire, New Jersey, Pennsylvania, Wisconsin and South Carolina in the United States, and from Newfoundland, Nova Scotia, Ontario and Quebec in Canada (Penney, 1960).

There were no previous records from Louisiana. During this survey it was collected from 16 localities in 13 parishes (Map 9) (Appendix). Although present in south Louisiana, it is more common in the northwestern area of the state.

Colonies consisted of encrusting growths usually only a few millimeters thick. In well developed colonies the surface was rugose. They were usually green due to symbiotic algae.

A. argyrosperma has spined megascleres and two types of gemmule birotulates typical of the genus Anheteromeyenia. It can be separated from its only Louisiana congener, A.

ryderi, by the 1 to 4 strongly recurved claw-like hooks which compose the rotule of the larger class of gemmule birotulates (Figure 36). In A. ryderi, the larger class of gemmule birotulates have a simple curve (Figure 36). The shafts of the larger gemmoscleres often bear recurved spines. The smaller class of birotulates have rotules consisting of many recurved hooks and shafts which are abundantly spined (Figure 37).

Wurtz (1950) summarized the works of Old (1932b) and Jewel (1935, 1937) and reported A. argyrosperma from waters with the following range of chemical conditions.

pH	4.2-7.5
SiO_2	3.8-7.5 ppm
Bound CO_2	17-54.15 ppm
Ca	1.2-22 ppm
Hardness as $CaCO_3$	40-80 ppm
Conductivity	90-205 micromhos

Penney (1954) reported it from one locality with the following chemical conditions.

pH	6.5
Bound CO_2	12.7 ppm
SiO_2	7.8 ppm
Ca	4.1 ppm

Ecological data gathered from five localities during this study are presented in Table 11 and summarized as ranges listed below.

pH	6.5-7.1
Free CO_2	4-22 ppm
Methyl Orange Alkalinity	20-85 ppm
Conductivity	80-750 micromhos
Temperature	24-31°C

Except for conductivity, the Louisiana data fall within the range given by Wurtz (1950). Jewel (1935, 1937)

characterized this species as restricted to waters of moderate hardness with continuous movement necessary for good growth. In Louisiana it was found in slightly acid waters moderate in alkalinity but relatively high in conductivity and was common in standing waters such as roadside swamps, sloughs, and lakes. It was found in habitats exposed to seasonal drying. Active colonies were encountered from May to September, but this was probably because areas in north Louisiana, where it was most abundant, were not frequently studied during winter months.

Radiospongilla crateriformis (Potts, 1882)

Figures 38, 39

1882 Meyenia crateriformis Potts, Proc. Acad. Nat. Sci. Phila., 34:12-14.

1968 Radiospongilla crateriformis, Penney and Racek, U. S. Nat. Mus. Bull., 272:66.

Penney and Racek (1968) record R. crateriformis from the United States, China, Japan and southeast Asia. In the United States it is known from Delaware, District of Columbia, Florida, Illinois, Indiana, Maryland, Michigan, New York, Ohio, Pennsylvania, Wisconsin, New Jersey, Texas, South Carolina and Tennessee (Penney, 1960). There were no previous records from Louisiana. The report from Louisiana (Moore, 1951) was based on a misidentification (Moore, 1953b).

During this study it was collected from 27 localities in 18 parishes scattered throughout Louisiana (Map 10) (Appendix). Colonies consisted of thin encrustations less than 1 mm in thickness. They were usually small but in some localities were limited in extent by the size of the available substrate. Under field conditions, they can be recognized by their thin growth form and small white gemmules.

Radiospongilla crateriformis is characterized by megascleres which are fusiform, sharply pointed amphioxea, microspined except at the tip. They ranged from 210 to 295

microns in length.

The gemmoscleres varied in Louisiana. They ranged from birotulate forms in which the rotules are formed by recurved spines, and with a few short spines on the shaft below the rotule (Figure 39) to forms in which the rotules were composed of a mass of irregularly arranged spines. In the latter forms the shafts were often completely covered with heavy spines which were often continuous with those of the rotules (Figure 40). Both forms ranged from 50 to 70 microns in length.

The gemmules ranged from 290 to 350 microns in total diameter. This included the pneumatic layer which ranged from 45 to 75 microns in thickness. There was a small crater-like depression around the foraminal tubule.

Penney and Racek (1968) established the genus Radiospongilla to include sponges with spined megascleres and with gemmoscleres defined as follows:

> Gemmoscleres rather slender amphioxea or amphisstrongyla, invariably strongly spined, ranging from moderately long to very long, and from straight to distinctly curved; their spines often conspicuously aggregated and larger in the scepter-like terminal structures, or pseudo-rotules of a varying degree of perfection.

In only five Louisiana localities were the gemmoscleres malformed with irregular or pseudorotules, that are characteristic of the genus Radiospongilla. In other localities the rotules were composed of a single row of delicate recurved spines. This type of variation has been reported by other workers but not associated with any particular set of ecological conditions. The variation in

Louisiana does not show any consistent relationship with the available chemical data.

Eshleman (1950) characterized this species as occupying a number of different habitats, but as the only species found in very stagnant or turbid waters. Wurtz (1950) reported it from one locality with the following range of chemical conditions.

pH	7.3
SiO_2	10.07 ppm
Bound CO_2	22.68 ppm
Ca	13.8 ppm
Hardness as CO_3	51.6 ppm
Conductivity	145 micromhos

Penney (1956) collected it from one locality in South Carolina along with the following data.

pH	6.5
Free CO_2	12.7 ppm
SiO_2	7.8 ppm
Ca	4.1 ppm

Ecological data accumulated during this study are presented in Table 12 and summarized as ranges below.

pH	6.6-7.1
Free CO_2	7-22 ppm
Methyl Orange Alkalinity	31-150 ppm
Conductivity	72-245 micromhos
Temperature	23-33°C

Data collected from Girard Park Lake, Lafayette Parish, were not included above because of their unusual nature. Girard Park Lake is small pond which receives overflow from the park swimming pool. Irregular chemical conditions could have influenced the dyes involved in the chemical analysis, so the results obtained may be accurate. Ecological data from this locality are as follows.

pH	9.2
Methyl Orange Alkalinity	40 ppm
Free CO_2	--
Phenolphthalein Alkalinity	6 ppm
Conductivity	265 micromhos

The pH is much higher than what has been reported for this species and most other species of fresh-water sponges.

Radiospongilla crateriformis appears to be seasonal in Louisiana, since active colonies were found only from May to September. Colonies reach their maximum development in size and number during late summer. Gemmules usually form in the fall, but colonies filled with gemmules were encountered during late spring and summer.

It was found in slightly acid to alkaline waters relatively high in bicarbonates and conductivity. It was absent from areas of acid drainage and green colonies due to symbiotic algae were never encountered. It was found in temporary waters where gemmules are exposed to drying. As reported by Eshleman (1950), in Florida it was often found in stagnant swamps, sloughs and sluggish streams.

Heteromeyenia baileyi (Bowerbank, 1863)

Figures 40, 41

1863 Spongilla baileyi Bowerbank, Proc. Zool. Soc. London, 1863:451.

1880 Spongilla repens Potts, Proc. Acad. Nat. Sci. Phila., 32:357.

1887 Heteromeyenia repens, Potts, Proc. Acad. Nat. Sci. Phila., 39:237.

1953 Heteromeyenia repens, Moore, Trans. Amer. Micr. Soc., 72:27.

1968 Heteromeyenia baileyi, Penney and Racek, Bull. U. S. Nat. Mus., 272:106.

The early history and synonomy of this species were given by Penney and Racek (1968). After reviewing a large collection of specimens from the United States, they regarded H. repens (Potts, 1880) as synonomous with H. baileyi.

According to Penney and Racek (1968), this species has been reported from Germany, Poland, Mexico and the United States. From the United States, Penney (1960) recorded it from Pennsylvania, Delaware, Florida, Indiana, Michigan, New Hampshire, New Jersey, New York and Louisiana. It was first reported from Louisiana by Moore (1953). During this survey it was found in 13 localities in 10 parishes mainly in northwest and south Louisiana (Map 9) (Appendix).

In Louisiana colonies were thin green encrustations

usually only a few millimeters thick. A few colonies collected in the Atchafalaya Swamp near Henderson, La., St. Martin Parish, were as thick as 5 mm and had projections extending as high as 1 cm from the substrate. Colonies were usually without gemmules.

Heteromeyenia baileyi is the only member of the genus Heteromeyenia Potts, 1881, as restricted by Penney and Racek (1968), in Louisiana. It can be distinguished from all other fresh-water sponges in the state by the presence of dermal spicules and birotulate gemmoscleres. The megascleres (Figure 40) are microspined except near the tips and range from 220 to 300 microns in length. The microscleres are straight to slightly curved amphioxea spined throughout their lenght with the spined increasing towards the central portion of the spicule (Figure 40) and ranged from 60 to 95 microns in length. The gemmoscleres are birotulates of two types, the smaller very abundant class range from 70 to 95 microns in length. They usually have spines all along the shaft and the rotules are composed of a number of recurved spines which are only slightly incurved forming an almost flat rotule. (Figure 41). The larger class ranged from 100 to 140 microns in total length. The spines which form the rotule varied considerably. In most collections they had a simple curve (Figure 41), while in some collections some were sharply incurved.

Jewel (1959) treated these forms as distinct species but did state that these differences may be due to ecology.

Two species could not be separated in Louisiana since there was considerable variation in the gemmules in a single colony. This supports the findings of Penney and Racek (1968) regarding synonomy. However the gemmule birotulates from Louisiana specimens were longer than those reported by Penney and Racek (1968). They reported the smaller class as ranging from 50 to 60 microns in length and the larger class from 80 to 85 microns in length.

The gemmules ranged from 450 to 600 microns in diameter. A simple tube was present but in most of the gemmules it was difficult to see since it usually did not project beyond the pneumatic layer.

Ecological data gathered from five Louisiana localities are presented in Table 13 and summarized as ranges below.

pH	6.6-6.9
CO_2	6-22 ppm
Methyl Orange Alkalinity	18-150 ppm
Conductivity	46-3,000 micromhos
Temperature	23-31°C

The high conductivity listed above was due to one collection from Bayou Du Zaire, St. Tammany Parish. Slightly brackish water sometimes enters through the Tchefuncte River from Lake Pontchartrain. The chloride concentration was 1.100 ppt.

Wurtz (1950) summarized the works of Old (1932b) and Jewel (1935, 1939) and gave the following range of chemical conditions for H. baileyi.

pH	4.2-8.4
SiO_2	0.25-5.6 ppm
Bound CO_2	1-125 ppm
Ca	2.66-53.4 ppm

Hardness as $CaCO_3$	40-100 ppm
Conductivity	14.5-60 micromhos

Penney (1953) reported it from one habitat with the following chemical conditions.

pH	6.7
Bound CO_2	6.1 ppm
SiO_2	7.0 ppm
Ca	1.5 ppm

Except for conductivity, the Louisiana data are within the wide range of chemical conditions reported by Wurtz (1950). H. baileyi is apparently capable of tolerating a wide range of chemical conditions and its restriction to certain habitats cannot be explained by existing chemical and physical data.

It was always green due to the presence of symbiotic algae. The habitat distribution may be due to its relationship with algae. If it were dependent upon algae for food, it would be restricted to areas where conditions necessary for photosynthesis exist.

In most habitats active colonies without gemmules were present throughout the year. In temporary habitats colonies formed gemmules in late spring before drying. It was usually found growing upon aquatic plants, but in some habitats it was on wood.

Dosilia radiospiculata (Mills, 1888)

Figures 42-44

1888 *Heteromeyenia radiospiculata* Mills, Ann. Mag. Nat. Hist., (6), 1:313-314.

1895 *Heteromeyenia plumosa* Weltner, Arch. f. Naturg., 61:127-128.

1909 *Heteromeyenia plumosa*, Annandale, Proc. U. S. Nat. Mus., 37:405-406.

1912 *Asteromeyenia radiospiculata*, Annandale, Proc. U. S. Nat. Mus., 40:593-594.

1953 *Asteromeyenia plumosa*, Moore, Trans. Amer. Micr. Soc., 72:24.

1968 *Dosilia heterogena* Penney and Racek, Bull. U. S. Nat. Mus. 272:131-132.

1968 *Dosilia radiospiculata*, Penney and Racek, Bull. U. S. Nat. Mus., 272:131-132.

Penney and Racek (1968) redefined the genus *Dosilia* Gray, 1867, to include all fresh-water sponges with aster-like microscleres (Figure 42). This made it possible to include, in a more natural arrangement, species which, at one time or another, had been assigned to the genera *Ephydatia* (=Meyenia), *Heteromeyenia* and *Asteromeyenia*.

In Louisiana, two species are involved, *Dosilia radiospiculata* (Mills, 1888) and *heterogena* Penney and Racek, 1968. The latter is a *nomen novum* for *Heteromeyenia plumosa* Weltner, 1895, since the transference

of this species to the genus Dosilia makes it a junior homonym of Dosilia plumosa Carter, 1849.

Penney and Racek (1968) indicated with some question that D. radiospiculata and D. heterogena are probably synonyms. They examined material from numerous localities in the United States, and were unable to clearly differentiate characters of two species.

My findings support the contention of synonymy. I was unable to distinguish two species in collections from Louisiana, Mississippi and Texas. Characteristics of both species occur in the same sponge, the same gemmule, or even on one spicule. The variations, as determined by experimental studies that are described later, are due to geographic isolation. Therefore, D. heterogena (=A. plumosa) is merely an ecological variant of D. radiospiculata. The description of D. radiospiculata by Penney and Racek (1968) follows:

> Megascleres slightly curved, slender, and distinctly fusiform amphioxea, ranging from entirely smooth to distinctly microspined; length range 290-400 microns, width range 14-23 microns.
>
> Microscleres moderately abundant in the symplasm and the vicinity of gemmules; they are stellate spicules consisting of 6-8 rays projecting from a distinct central nodule; the rays usually microspined, terminating in a small number of minute recurved distal spines arranged in the shape of a small rotule; occasionally transitional amphioxous microscleres, distinctly granulated, and bearing in their central portion a number of perpendicular long rays; length range of microscleres extremely variable.
>
> Gemmoscleres of two conspicuously distinct classes: (1) Birotulates of slightly but distinctly unequal length, with a strongly spined cylindrical shaft, and terminally with umbonate

rotules of equal diameter whose margins bear an irregular arrangement of triangular teeth; and (2) extremely long birotulates of greatly varying length, their shafts often bent and smooth, occasionally bearing a few spines, their rotules represented by a small number of strongly recurved hooks; shaft cylindrical, as a rule distinctly fusiform, resembling the shape of megascleres; length range of (1) 45-82 microns, thickness of shaft 8-19 microns, diameter of rotules 22-26 microns; length range of (2) 120-230 microns, thickness of shaft in central portion 16-20 microns.

Gemmules spherical, ranging in diameter 540-610 microns; pneumatic coat well developed, consisting of minute spherical air spaces; smaller class of gemmules within this coat, larger class invariably projecting through its outer surface, often for a great distance; foramen produced into a short and straight tube, projecting through pneumatic coat but not surpassing its outer surface.

Dosilia heterogena was originally separated from D. radiospiculata on the basis of the form of the terminal spines of the longer gemmule spicules. In the former the spines which form the rotule have a simple curve (Figure 43), while in the latter the tips are distinctly recurved so that the whole spine as seen in profile has almost the form of a capital letter J (Figure 44) (Annandale, 1912).

This species was first reported from Louisiana by Annandale (1912). One specimen measuring 29 by 25 cm was found with Trochospongilla leidyi in the settling tanks of the Shreveport waterworks. Penney and Racek (1968) examined material in Gee's collection from Loyola University, New Orleans, Louisiana.

Dosilia radiospiculata is known only from the United States. Penney (1960) reported it from California, Florida, Louisiana, Illinois, Ohio and Texas and Penney and Racek (1968) reported if from Arkansas Oklahoma and Alabama.

I had difficulty in finding this species in Louisiana even though I had obtained specimens from southwest Texas and northeastern Mississippi. In those states it was often associated with limestone, in water and drainage areas high in bicarbonates and total dissolved solids. I searched areas along the Mississippi River floodplain and oxbow lakes of the Mississippi River, as well as areas near Shreveport, near the site of the original discovery. Finally, I encountered it in Old Lake at Lake End, La., Red River Parish, where large colonies 8 by 10 cm in diameter were growing upon the roots and stems of a mat of alligator weed extending from the shoreline.

Since Old Lake is an oxbow lake of the Red River, I searched lakes of similar origin. Wilson Lake at La. Hwy 1 an oxbow lake northwest of Plain Dealing, La., Bossier Parish, were searched without finding sponges. These lakes were difficult to find and most were inaccessible by automobile.

In early September of 1968 near Natchitoches, La., Natchitoches Parish, large colonies were found in every lake of Red River origin that I examined. It was at the following five localities.

Natchitoches Parish: Cane River Lake off La. Hwy. 6 Natchitoches, La., September 5, 1968; Old River at Powhatan, La. September 5, 1968; Cane River Lake off La. Hwy. 1223 S of Natchitoches, La., September 6, 1968.

Rapides Parish: Mill Pond, Zimmerman, La., September 6, 1968.

Red River Parish: Old Lake at Lake End, La., August 9, 1968.

The ecological data collected at these localities are presented in Table 1 and summarized as ranges below:

pH	7.3-7.9
Free Carbon Dioxide	3-9 ppm
Methyl Orange Alkalinity	74-115 ppm
Conductivity	118-293
Water Temperature	25-31oC

Dosilia radiospiculata appears to be limited to alkaline waters relatively high in bicarbonate alkalinity and conductivity, present along the Red River floodplain.

Since I investigated this species in habitats only during August and September little can be said regarding its seasonal distribution in Louisiana. Cheatum and Harris (1953) found active colonies throughout the year in Hutchins Lake, Dallas County, Texas. They measured small colonies in October, which grew throughout the year, and reached their maximum size by October of the next year.

Colonies, without gemmules, collected from Old River at Powhatan, La., Natchitoches Parish, were used for experimental studies of environmental variation. Gemmules collected from this habitat were typical of D. radiospiculata. Colonies about 1 by 2 cm in diameter were exposed to the following experimental conditions:

(1) 250 ml of habitat water with 200 ml of concentrated habitat water added in 25 ml portions over a 2 day period. The concentrated habitat was prepared by boiling 500 ml of

habitat water to 200 ml. This exposed the colony to higher concentrations of the same minerals present in the natural environment. The colony remained healthy and within two weeks gemmules formed throughout the sponge colony. The gemmules which formed had gemmoscleres typical of D. heterogena (Figure 44) instead of D. radiospiculata (Figure 45) present in the natural habitat.

(2) 250 ml of habitat water with 200 ml of distilled water added in 50 ml portions over a 3 day period. The colony released larvae for the first week and later gemmule formation began. After two weeks the colony was simply a mass of gemmules. As in experiment (1) the gemmoscleres which formed were typical of D. heterogena.

(3) 250 ml habitat water with 5 ml of seawater added. The colony died within two days without forming gemmules.

(4) 250 ml habitat with 2 g $CaCO_3$ added. Reagent $CaCO_3$ in the solid precipitated form was added directly and allowed to slowly go into solution to increase the concentration of bicarbonate. The sponge died within two weeks without forming gemmules.

(5) 250 ml habitat water served as a control. After a week the colony began to appear unhealthy and in the week that followed became reduced and disintegrated. This colony was in poor condition when collected, but had to be used since live colonies were limited. The better specimens were reserved for the more rigorous experimental conditions. The specimens from the natural habitat served as a basis for comparison.

The gemmoscleres which were produced under experimental conditions (1) and (2) were typical of *D. heterogena*, while those which formed in the natural habitat were typical of *D. radiospiculata*. The change in the form of the gemmoscleres under experimental conditions was probably due to insufficient available silica involved in the production of a large number of gemmules throughout the colonies in both experiments.

IV. KEY TO SPECIES OF LOUISIANA SPONGILLIDAE

1. Microscleres present.....2
   Microscleres absent.....4
2. Microscleres small asters (Fig. 42)...*D. radiospiculata*.
   Microscleres spined amphioxea (Figs. 1, 2).....3
3. Gemmoscleres acerate (Fig. 2).....*S. lacustris*.
   Gemmoscleres birotulate (Fig. 41).....*H. baileyi*.
4. Gemmoscleres acerate.....5
   Gemmoscleres birotulate.....6
5. Megascleres smooth (Fig. 17).....*E. fragilis*.
   Megascleres spined (Fig. 18).....*E. mackayi*.
6. Gemmoscleres large (greater than 15 microns long); rotules composed of spines with serrate margins.....8
   Gemmoscleres small (less than 15 microns long); rotules with smooth margins.....7
7. Megascleres smooth (Fig. 30).....*T. leidyi*.
   Megascleres spined (Fig. 28).....*T. pennsylvanica*.
8. Gemmoscleres all of one type.....9
   Gemmoscleres of two distinct types.....10
9. Gemmoscleres with large flat rotules (Figs. 4-15)..... *E. fluviatilis*.
   Gemmoscleres with small rotules composed of recurved spines often irregular (Figs. 38, 39)..*R. crateriformis*.

10. Rotules of smaller class of birotulates with finely serrate margins (Fig. 31).....A. ryderi.
Rotules of smaller class of birotulates indistinct, margin coarsely serrate (Fig. 37).....A. argyrosperma.

V. DISCUSSION AND CONCLUSION

The relative abundance of species of Louisiana Spongillidae is presented in Table 1. Common widespread species such as T. pennsylvanica and E. fragilis were those which were able to tolerate a wide range of physical and chemical conditions. Rare species such as Eunapius mackayi and Dosilia radiospiculata were restricted to certain areas by their narrow ecological tolerances. The distribution and abundance of Louisiana fresh-water sponges were dependent upon existing habitat conditions and not distinct barriers which impede dispersal.

Ecological associations of species of Louisiana Spongillidae are presented in Table 2. These are not chance occurrences but are indicative of definite ecological relationships. The species found together have similar ecological requirements.

Abundant species able to tolerate a wide range of ecological conditions were often found with many other species. Trochospongilla pennsylvanica was found with all other species except D. radiospiculata. It was found most often with E. fragilis another species which occurs over a wide range of ecological conditions.

Rare species with restricted ecological tolerances were associated with a few other species. Dosilia radiospiculata was found four out of five times with T. leidyi and

was not found with any other species. Trochospongilla leidyi is the only species able to tolerate conditions which are favorable for D. radiospiculata. Eunapius mackayi, which is limited to acid waters low in bicarbonates and other dissolved solids, was found with S. lacustris, T. pennsylvanica and A. ryderi which are able to tolerate these conditions.

Seasonal distribution and physical conditions of the habitat are also important in understanding these associations. Trochospongilla pennsylvanica was found 15 times with R. crateriformis. Both of these species are abundant during late summer in sloughs and ditches subject to silting, high temperatures and drought conditions which are unfavorable to the growth of other species.

The available literature concerning gemmule formation and seasonal occurrence is confusing. According to Potts (1918), gemmules may form as early as August and as late as November. Annandale (1911) stated that gemmules are produced at the approach of winter. Old (1932b) found specimens of most species of Michigan fresh-water sponges with gemmules early in any favorable season, with S. lacustris being the only species which appeared to delay gemmule formation until winter. Cheatum and Harris (1953) found E. fragilis, D. radiospiculata and T. pennsylvanica producing gemmules throughout the year near Dallas, Texas. They found that the growth of these species was perennial and suggested that it was due to the frequent reoccurrence of low temperatures.

Penney (1956) found gemmules in fresh-water sponges in South Carolina in every month of the year. He suggested that while gemmules allow the sponge to survive unfavorable conditions, they were probably produced in the process of "maturation".

Moore (1953), in south Louisiana, found gemmule-bearing sponges from November through June; specimens collected toward the end of this period were usually in a state of disintergration. He stated that the seasonal variation in occurrence of sponges in south Louisiana was related to their inability to tolerate water temperatures over 30°C.

In Louisiana it is possible to find sponges with gemmules throughout the year, since gemmules do form in the basal regions of most encrusting sponges as they mature. However, the cessation of growth and the rapid formation of gemmules throughout the sponge is seasonal. Large colonies are not the result of several years growth, but may arise from gemmules and grow as thick as two inches within three months. Most species appear to have an annual life cycle in Louisiana. There are distinct seasonal trends in occurrence, period of active growth, and period of gemmule formation in most species.

Ephydatia fluviatilis, Anheteromeyenia ryderi and Eunapius fragilis have distinct seasonal distributions. They are abundant during fall, winter and early spring. Colonies reach their maximum size in the spring as water temperature approaches 30°C and gemmules form which germinate later in

the fall. This cycle is especially apparent in temporary habitats which are subject to drying during the summer months. While temperature appears to be the most important factor influencing gemmule formation, at this time it does not limit sponge growth since active colonies were found in late summer exposed to temperatures above 30°C. Anheteromeyenia ryderi was found in streams during the summer months, but growth was more rapid and large colonies were abundant during winter. Although E. fragilis could be found throughout the year, large colonies had a distinct seasonal cycle in temporary habitats with germination in the fall, growth throughout the winter, and gemmule production in the spring. In other habitats such as streams north of Lake Pontchartrain, gemmules germinate in the spring, colonies grow throughout the summer, with gemmules again forming in the fall.

Active colonies of Trochospongilla leidyi and Radiospongilla crateriformis although common during spring and summer were not found during the winter. In Trochospongilla leidyi gemmules germinate in the spring and are produced in the fall. Radiospongilla crateriformis appears to have short eratic periods of growth during the summer. Trochospongilla pennsylvanica appears to have a similar seasonal cycle, since colonies were rarely encountered in the winter and most abundant in the summer. Gemmules usually formed in the fall, but in some localities they formed in early summer.

Spongilla lacustris has a distinct seasonal cycle in

Lake Pontchartrain, with gemmules forming in the fall but in other localities such as small streams and lakes colonies were found throughout the year.

Heteromeyenia baileyi was found throughout the year, but most collections were without gemmules. In temporary habitats gemmules formed in late spring.

Anheteromeyenia argyrosperma was found only during spring and summer; areas in north Louisiana where it was most abundant were not studied during the winter months.

Dosilia radiospiculata and Eunapius mackayi were not abundant enough to furnish evidence for generalizations concerning their relative seasonal abundance. Dosilia radiospiculata was found late in the study in August and September, Eunapius mackayi seems to be present throughout the year.

The seasonal abundance and period of gemmule formation varied in all species with habitat conditions. Small colonies do not follow seasonal trends in habitats frequently exposed to adverse conditions. These may form gemmules under adverse conditions and grow during favorable conditions. Gemmules may form at any time, as evidenced by the formation of gemmules by sponges maintained in the laboratory.

The spicules, particularly the gemmoscleres of all Louisiana fresh-water sponges, were subject to morphological variation. There is very little information concerning the nature of this variation in the literature. Early workers

such as Potts (1887) were aware of it, but offered no explanation for its existence. Jewel (1935) found that the spicules of S. lacustris and T. pennsylvanica varied with the silicon and mineral content of the water. Jorgensen (1944) demonstrated that spicule formation in S. lacustris depends upon the concentration of dissolved silica in the medium.

In my master's thesis (Poirrier, 1965) I correlated variation in S. lacustris with habitat conditions. During the present study, variation in other species was investigated. It was necessary to determine if this variation were phenotypic in nature in order to solve taxonomic problems. From these laboratory studies and field observations similar trends are apparent in different species.

While the full development of spicules is limited by insufficient amounts of sicilia and other materials necessary for gemmule formation, much of the variation is not caused by limiting factors, but appears to be individual adaptations to habitat conditions.

Generally in waters which are low in pH, alkalinity and other minerals, the pneumatic layers of the gemmules were poorly developed and gemmoscleres delicate and fewer in number. In typical birotulate forms such as E. fluviatilis, A. ryderi and R. crateriformis gemmoscleres with perfectly formed rotules and without spines along the shafts were present in waters with these conditions. In alkaline waters high in mineral content, gemmoscleres with irregular rotules

and with spines along the shafts were produced. These were embedded in a thick pneumatic layer.

In Trochospongilla pennsylvanica the rotules are unequal in acid waters low in mineral content and equal in alkaline waters high in mineral content. Spongilla lacustris had gemmules without gemmoscleres or with a few poorly developed gemmoscleres in waters low in alkalinity and mineral content, while in waters which are high in pH and mineral content large robust spicules are arranged almost radially in a thick pneumatic layer.

This variation may be an adaptation of the sponge to conditions in which the gemmule is exposed to drying. The function of the gemmoscleres is apparently to protect the gemmule from mechanical damage and to protect the cellular contents of the gemmule from extreme dissication. If limnological conditions are such that drying is possible, gemmules are produced with a well-developed pneumatic layer and many robust gemmoscleres. The birotulate gemmoscleres formed under these conditions have abundant spines along their shafts. They fit close together and their rotules overlap, forming a thick flexible layer with the pneumatic material in between and covering the outer surface of the gemmule.

This type of gemmule is not of value in habitats which are not exposed to drying. They would be low in pH alkalinity and dissolved solids. Sponges could exist in this type of habitat without producing gemmules capable of with-

standing drought conditions and would allow them to prosper in environments where the materials needed to construct this type of structure are limited.

The laboratory experiments seem to support the above ideas, but results were not consistent, since the form of the gemmoscleres produced by the colonies in the laboratory depends not only on the amount of available silica in the medium but also the amount of silica stored in the sponge. The physiological condition of the sponge and conditions to which it had been previously exposed are probably also important. The number of gemmules produced under laboratory conditions is also important. If many gemmoscleres are produced the stored and available silica would be used to form many thin gemmoscleres instead of fewer robust ones. The amount of available silica and other conditions change as spicules form, those which are formed earlier are usually more robust than those formed later, since a limited amount of silica is available in the medium. Those which are formed later do so under conditions of greatly reduced silica concentrations. The laboratory studies do indicate that factors other than silica are important in determining the form of the gemmoscleres.

Many factors are responsible for the habitat distribution of fresh-water sponges in Louisiana, but correlations with limnological conditions are apparent. Jewel (1937) proposed that calcium in the form of calcium bicarbonate was

the most important factor in explaining the distribution of fresh-water sponges in Wisconsin. There are definite relationships between habitat selection and bicarbonate alkalinity in Louisiana. Trochospongilla leidyi and Eunapius fragilis were the only species present in the alkaline oxbow lakes of Mississippi River origin, and D. radiospiculata seems to be limited to alkaline waters of Red River origin.

Eunapius mackayi was limited to acid waters low in bicarbonates and total minerals. Spongilla lacustris, T. pennsylvanica and A. ryderi were common in acid areas low in bicarbonates such as the pine areas of the Florida Parishes. Spongilla lacustris (Jewel, 1935) tolerates a wide range of chemical conditions. In Louisiana it was common in areas of acid drainage, but was also present in brackish water. Trochospongilla pennsylvanica was found in areas of moderate alkalinity and in areas with a slight brackish water influence. Anheteromeyenia ryderi was present in slightly alkaline waters along the Mississippi River floodplain where it usually occurred with E. fragilis. In similar habitats which were high in alkalinity only E. fragilis was present, indicating that it is limited by water of high alkalinity.

All other species were absent from waters low in bicarbonates in areas of acid drainage. Ephydatia fluviatilis and T. leidyi were found in areas of high conductivity due to calcium bicarbonate or sodium chloride and favored alkaline conditions. Ephydatia fluviatilis was common in brackish-

water areas and was present in high salinity regions of Lake Pontchartrain. Trochospongilla leidyi was present in slightly brackish-water areas and is probably limited to waters with salinities below 2 ppt.

Radiospongilla crateriformis prefers alkaline waters and was often found in stagnant sloughs and swamps. Anheteromeyenia argyrosperma and H. baileyi were always bright green due to the presence of symbiotic algae. Their habitat distribution may be dependent upon this algal relationship, limiting them to areas exposed to sunlight of proper intensity. Wurtz (1950) reported H. baileyi from a wide range of chemical conditions. In Louisiana it was present in slightly acid waters which varied in other conditions. It was present in one brackish-water locality and was almost always found growing upon plants. Anheteromeyenia argyrosperma was found in slightly acid waters of moderate alkalinity but relatively high in conductivity (80 to 750 micromhos).

Eunapius fragilis, although not common in acid waters, was present in slightly acid waters low to moderate in alkalinity. It was most common in waters of moderate alkalinity and conductivity, and was rare in waters high in alkalinity and conductivity, but never was found in brackish water.

Other factors such as temperature and turbidity have been reported as influencing the distribution of fresh-water sponges. Moore (1953) reported that healthy sponge colonies were never taken at water temperatures above 30°C and when

E. fluviatilis, A. ryderi and H. baileyi were collected at this thermal threshold they were in the process of disintergration. Old (1932b) found that T. pennsylvanica, H. baileyi, and A. argyrosperma were not found at "colder temperatures", neither were they found at temperatures above 27°C. Active colonies of all species of Louisiana freshwater sponges, with the exception of E. mackayi, were taken from waters above 30°C. While high temperatures in early spring seem to be related to gemmule formation and the termination of seasonal growth in some species, it does not limit sponge growth at other times during the year.

Potts (1918) reported that sponges do not occur in sluggish streams and shallow muddy ponds, but Old (1932b) found large colonies growing upon mud bottoms of ponds. Moore (1953b) stated that abundant suspended material definitely limits sponge growth. Cheatum and Harris (1953) reported colonies of T. pennsylvanica and R. crateriformis from very silty waters. All Louisiana species are probably capable of withstanding brief periods of high turbidity, but prolonged periods of high turbidity due to suspended silt limit the growth of most species.

Trochospongilla pennsylvanica, T. leidyi, R. crateriformis and E. fragilis seemed to be most tolerant of silt and silty waters. This is related to their encrusting growth form. The thickness and diameter of colonies of these species are definitely limited by these conditions. Ephydatia

fluviatilis was the only species in which large colonies were often collected from silty waters.

The restriction of sponge colonies to the undersides of substrate in some habitats is probably due to the difficulty of larval attachment to the upper surface of a silty substrate. If located below, as suggested by Potts (1918), the colonies are protected from being covered with silt and gravity helps them in riding themselves of unwanted silt.

Sponges were found growing upon every conceivable substrate available in the fresh-water environment. Most species preferred wood and were seldom found growing upon metalic objects. Heteromeyenia baileyi was usually growing upon aquatic plants. Ephydatia fluviatilis and R. crateriformis were found growing upon plants as well as other substrates. Other species, especially those with encrusting growth forms, were seldom found upon aquatic plants, but Eunapius fragilis, T. pennsylvanica and T. leidyi, under optium conditions, were sometimes associated with plants, particularly plants with broad leaves and large stems.

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Table 1

Comparative Abundance of Louisiana Spongillidae

Species	Number of Collections	Percentage of total	Order of abundance
Spongilla lacustris	28	9.1	5
Ephydatia fluviatilis	16	5.2	7
Eunapius fragilis	51	16.5	2
Eunapius mackayi	4	1.3	11
Trochospongilla pennsylvanica	90	29.1	1
Trochospongilla leidyi	31	10.0	4
Anheteromeyenia ryderi	32	10.4	3
Anheteromeyenia argyrosperma	12	3.9	9
Radiospongilla crateriformis	27	8.7	6
Heteromeyenia baileyi	13	4.2	8
Dosilia radiospiculata	5	1.6	10
Total collections	309		

Table 2

Frequency of Associations Among Species of Louisiana Spongillidae.

	S. lacustris	E. fluviatilis	E. fragilis	E. mackayi	T. pennsylvanica	T. leidyi	A. ryderi	A. argyrosperma	R. crateriformis	H. baileyi	D. radiospiculata
S. lacustris		4	2	2	8	5	6	3	1	1	0
E. fluviatilis	4		1	0	2	3	1	0	0	1	0
E. fragilis	2	1		0	28	7	9	7	8	5	0
E. mackayi	2	0	0		2	0	2	0	0	0	0
T. pennsylvanica	8	2	28	2		13	9	11	15	6	0
T. leidyi	5	3	7	0	13		0	1	1	1	4
A. ryderi	6	1	9	2	9	0		3	1	2	0
A. argyrosperma	3	0	7	0	11	1	3		4	1	0
R. crateriformis	1	0	8	0	15	1	1	4		4	0
H. baileyi	1	1	5	0	6	1	2	1	4		0
D. radiospiculata	0	0	0	0	0	4	0	0	0	0	

Table 3

Spongilla lacustris, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
St. Helena Parish, Creek at La. Hwy 37	6.1	13	14	37	21
St. Tammany Parish, Abita Creek, 2.5 mi E Abita Springs	6.9	11	75	130	33
St. Tammany Parish, Tchefuncte River 0.5 mi S of Madisonville	7.1	3.5	26	2,700	32
Winn Parish, Saline Bayou	6.6	6	16	170	26

Table 4

Ephydatia fluviatilis, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Chloride ppt	Water Temperature °C
Cameron Parish, Marsh, Canal	-	-	-	1,200	0.580	-
Jefferson Parish, Temporary Pool, Waggaman	7.2	19	72	-	-	25
Jefferson Parish, Kenta Drainage Canal 3/23/64	6.7	10	25	=	-	17
same 4/23/64	6.5	13	19	-	-	20
same 5/20/64	7.1	11	-	-	-	25
same 6/25/64	7.4	5	69	-	-	31
same 7/29/64	6.9	18	114	-	-	29
same 8/30/64	7.0	15	96	-	-	29
same 9/27/64	7.3	4	72	-	-	27
Orleans Parish, City Park Back Lagoons, N. O. La. 2/15/64	-	-	-	-	2.6	-

Table 4

(Continued)

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Chloride ppt	Water Temperature °C
Orleans Parish, City Park N. O. La. 4/14/64	7.2	3	23	-	-	22
same 8/1/64	7.2	8	54	-	-	31
same 8/2/68	6.7	-	24	-	-	33
Plaquemines Parish, Delta Duck Pond	-	-	-	-	-	31
Pointe Coupee Parish, slough at Hwys 1 & 90	7.7	-	200	350	0.016	27
St. Tammany Parish Tchefuncte River 1 mi S of Madisonville, La.	-	-	-	2,950	1.025	-
St. Tammany Parish Tchefuncte River 0.5 mi S of Madisonville, La.	7.1	4	26	2,700	0.950	32
Tangipahoa Parish, South Pass Manchac at Hwy 51	7.3	-	-	2,163	0.81	31
Vermillion Parish, Marsh Canal	-	-	-	1,900	0.520	-

Table 5

Eunapius fragilis, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Phenolphthalein Alkalinity ppm	Conductivity microhms/cm	Water Temperature °C
Assumption Parish, Bayou Pierre Part	7.4	6	120	-	-	30
Iberville Parish, Bayou Maringouin	8.7	00	185	15	-	26
Iberville Parish south of Ramah, La.	6.9	22	115	-	760	34
Madison Parish, Indian Lake	8.1	2	60	-	110	34
St. Charles Parish, south of Boutte, La.	6.6	12	52	-	-	23
St. Helena Parish, Ditch near Greensburg, La.	6.5	12	17	-	37.5	31
St. Landry Parish, west of Krotz Springs, La.	7.3	14	125	-	-	25
St. Martin Parish, north of Henderson, La.	6.9	22	85	-	163	28
St. Tammany Parish, Bayou Chincuba	7.1	18	150	-	245	29
West Baton Rouge Parish, east of Rosedale, La.	7.4	21	230	-	430	26

Table 6

Trochospongilla pennsylvanica, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
East Feliciana Parish, Beaver Dam at Hwy 10	6.6	6	18	46	31
Jackson Parish, Caney Creek at Hwy 34	6.5	9	28	39.5	31
St. Martin Parish, Atchafalaya Swamp at west levee	6.9	22	85	163	28
St. Tammany Parish, Abita Creek at Hwy 435	5.9	15	21	-	26
St. Tammany Parish, Evans Creek at Hwy 41	5.4	29	9.9	-	23
St. Tammany Parish, Ditch off gravel road W of Bayou Liberty	6.3	6	14	-	30

Table 7

Trochospongilla horrida, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Phenolphthalein Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
Caddo Parish, Black Bayou at Hwy 2	6.8	5	28	-	220	31
Iberville Parish, Bayou Maringouin	8.7	0.0	185	15	-	26
Jackson Parish, Chattam Lake at Dam	6.7	6.5	25	-	45	34
Madison Parish, Indian Lake	8.1	2	60	-	110	34
Natchitoches Parish, Black Lake at Hwy 9	6.9	4	30	-	80	31
Red River Parish, Grand Bayou at Hwy 784	6.6	14	33	-	103	26
St. Martin Parish, Bayou Teche at State Park	7.1	12	95	-	185	29
St. Tammany Parish, Abita River at Hwy 35	6.4	11	41	-	-	26
St. Tammany Parish, Bayou Castine at US Hwy 190	7.5	6	130	-	-	30
St. Tammany Parish, Cane Bayou at US Hwy 190	6.6	11	55	-	-	30

Table 7

(Continued)

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Phenolphthalein Alkalinity ppm	Conductivity micromhos/cm	Water Temperatures °C
St. Tammany Parish, Tchefuncte River at Hwy 21	6.3	6	12	-	-	28
St. Tammany Parish, Bayou Du Zaire at Hwy 21	6.3	-	28	-	-	30
St. Tammany Parish, Bogue Falaya River at US Hwy 190	6.5	7	14	-	-	25
St. Tammany Parish, Bayou Lacombe at US Hwy 190	5.7	12	13	-	-	28
St. Tammany Parish, Big Branch Bayou at US Hwy 190	6.8	8.5	44	-	-	31
St. Tammany Parish, Bayou Liberty at US Hwy 190	5.5	15	12	-	-	26
Tangipahoa Parish, lake east of Amite, La.	6.7	3	11	-	41	27
Terrebonne Parish, canal off La. Hwy 20	6.9	10	60	-	204	32
Winn Parish, Range Creek east of Saline Lake	7.1	9	70	-	141	25

Table 8

Trochospongilla pennsylvanica, *T. horrida* intermediates, Ecological Data.

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
Winn Parish, Dugdemona River at US Hwy 167	-	-	-	133	-
Winn Parish, Slough off La. Hwy 126	6.4	8	29	41	29
Winn Parish, Saline Bayou at Cloud Crossing Recreation Area	6.6	6	16	170	26

Table 9

Trochospongilla leidyi, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Phenolphthalein Alkalinity ppm	Conductivity micromhos/cm	Chloride ppt	Water Temperature °C
Assumption Parish, Bayou Piere Part	7.4	6	120	-	-	-	29.5
Assumption Parish, Lake Palourde	-	-	-	-	320	-	34
Caddo Parish, Black Bayou at Hwy 2	6.8	5	28	-	220	-	31
Iberville Parish, Bayou Maringouin	8.7	0.0	185	15	-	-	26
Jefferson Parish, Kenta Canal 6/25/64	7.4	5	69	-	-	-	31
same 7/25/64	6.9	18	114	-	-	-	29
same 8/30/64	7.0	15	96	-	-	-	29
same 9/27/64	7.3	4	72	-	-	-	28
Madison Parish, Indian Lake	8.1	2	60	-	110	-	34
Natchitoches Parish, Black Lake at Hwy 9	6.9	4	30	-	80	-	31
Natchitoches Parish Cane R. Lake	7.7	5	110	-	260	-	25

Table 9

(Continued)

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Phenolphthalein Alkalinity ppm	Conductivity micromhos/cm	Chloride ppt	Water Temperature °C
Natchitoches Parish, Old River	7.9	2	100	-	258	-	27
Natchitoches Parish, Cane River Lake S of Natchitoches	7.5	8	115	-	293	-	31
Rapides Parish, Mill Pond Zimmerman, La.	7.5	5	100	-	190	-	29
St. Landry Old Bayou Courtableau	7.7	6	160	-	310	-	31
St. Martin Parish, Bayou Teche	7.1	14	95	-	185	-	29
St. Tammany Parish, Tchefuncte R. S of Madisonville, La.	7.1	3	26	-	2,700	0.95	32
St. Tammany Parish, Tchefuncte R. N of Madisonville, La.	-	-	-	-	-	0.88	-
St. Tammany Parish, Bayou Du Zaire	-	-	-	-	3,000	1.10	31
Tangipahoa Parish, South Pass Manchac	7.3	-	-	-	2,163	0.81	-

Table 10

Anheteromeyenia ryderi, Ecological Data

	pH	Free CO2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
St. Charles Parish, S of Boutte, La.	7.1	10	128	-	32
St. Helena Parish, Creek at La. Hwy 37	6.1	13	14	37	21
St. Tammany Parish, ditch off gravel road, W of B. Liberty	5.2	12	4	-	20
St. Tammany Parish, Swamp at US Hwy 90 and 190	6.0	22	25	-	27
St. Tammany Parish, Bogue Falaya River at La. Hwy 40	6.0	11	11	-	23
St. Tammany Parish, Beason Creek at La. Hwy 40	5.9	9	10	-	23
St. Tammany Parish, slough near Pearl River Lock 1	5.9	9.5	17	-	28
St. Tammany Parish, Cypress Swamp near Florenville, La.	5.2	4	4	-	20
Winn Parish, Saline Bayou	6.6	6	16	170	26

Table 11

Anheteromeyenia argyrosperma, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
Bossier Parish, Ivan Lake at La. Hwy 529	6.6	7	32	72	31
Natchitoches Parish, Black Lake at La. Hwy 9	6.9	4	30	80	31
St. Martin Parish, Atchafalaya Swamp at W levee.	6.9	22	85	163	28
St. Tammany Parish, Abita River after confluence with Abita C.	7.1	5	70	130	24
Winn Parish, Saline Lake at Lyle's Camp	6.5	9	20	750	28

Table 12

Radiospongilla crateriformis, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Phenolphthalein Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
Bossier Parish, Ivan Lake at La. Hwy 529	6.6	7	32	-	72	31
Lafayette Parish, Girard Park Lake	9.2	0.0	40	6	265	32
St. Martin Parish, Swamp north of Henderson, La.	6.9	22	85	-	163	28
St. Tammany Parish, Pool off Bogue Falaya River	7.0	15	95	-	-	28
St. Tammany Parish, Bayou Chincuba at west causeway approach	7.1	18	150	-	245	29
St. Tammany Parish, Bayou Chincuba at Hwy 59	6.9	9	100	-	-	29
Terrebonne Parish, canal east of Gibson, La.	6.9	10	60	-	205	32
East Carrol Parish, Pond off La. Hwy 2	-	-	-	-	-	33

Table 13

Heteromeyenia baileyi, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
East Feliciana Parish, Beaver Dam at Hwy 10	6.6	6	18	46	31
St. Martin Parish, Atchafalaya Swamp at west levee	6.9	22	85	163	23
St. Tammany Parish, Bayou Chincuba at W causeway approach	7.1	18	150	245	29
St. Tammany Parish, Bayou Du Zaire at Hwy 21	-	-	-	3,000	-
Terrebonne Parish, Canal south of Hwy 20	6.9	10	60	205	32

Table 14

Dosilia radiospiculata, Ecological Data

	pH	Free CO_2 ppm	Methyl Orange Alkalinity ppm	Conductivity micromhos/cm	Water Temperature °C
Natchitoches Parish, Cane River Lake off La. Hwy 6	7.7	5	110	260	25
Natchitoches Parish, Old River at Powhatan, La.	7.9	3	100	258	27
Natchitoches Parish, Cane River Lake off La. Hwy 1223	7.5	8	115	293	26
Rapides Parish, Mill Pond at Zimmerman, La.	7.5	5	100	293	29
Red River Parish, Old Lake at Lake End, La.	7.3	9	74	118	31

Figure 1. Photomicrograph of smooth megascleres and spined microscleres of Spongilla lacustris. 180X.

Figure 2. Photomicrograph of gemmoscleres of Spongilla lacustris. 750X.

Figure 1

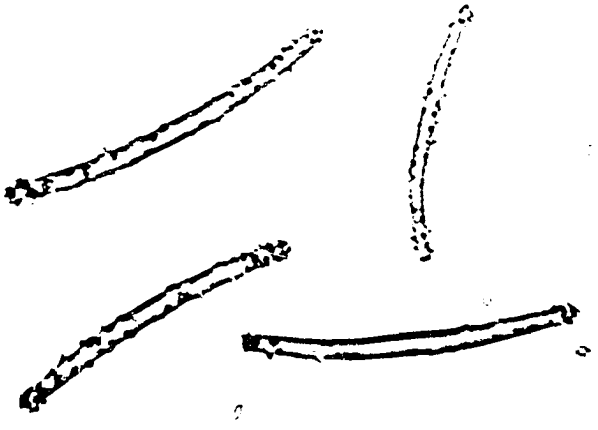
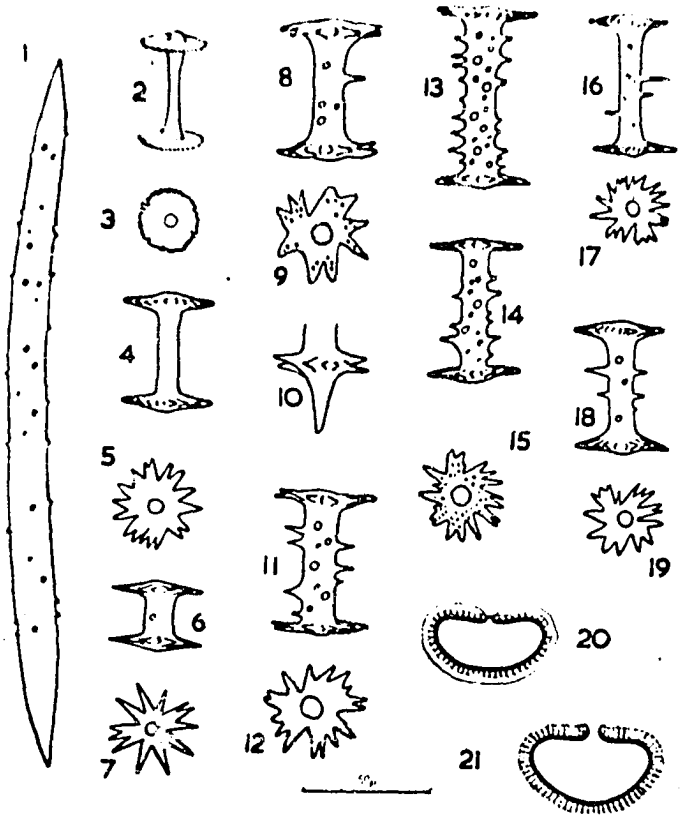


Figure 2

Figure 3. Reproduction of Plate 7 from Penney and Racek (1968) illustrating gemmoscleres of various species of the genus Ephydatia. 4 and 5, E. fluviatilis; 11 and 12, E. robusta.

Figure 3



Figures 4-12. Photomicrographs of gemmoscleres of *Ephydatia fluviatilis* produced under experimental conditions. 750X.

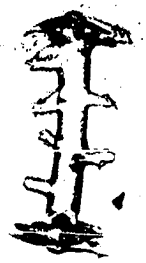


Figure 4

Figure 5

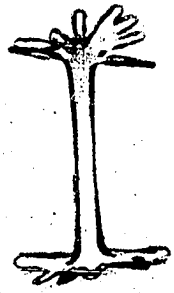


Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

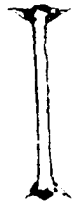


Figure 11

Figure 12

Figure 13. Photomicrograph of gemmosclere of Ephydatia fluviatilis produced under experimental conditions. 750X.

Figure 14. Photomicrograph of smooth and spined megascleres and gemmosclere of Ephydatia fluviatilis produced under experimental conditions. 350X.

Figure 15. Photomicrograph of gemmoscleres of Ephydatia fluviatilis produced under experimental conditions. 750X.

Figure 13

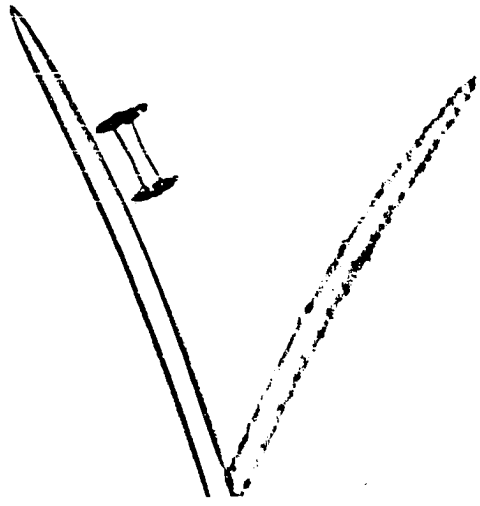


Figure 14

Figure 15

Figure 16. Photograph of the surface of a colony of Eunapius fragilis. Natural size.

Figure 17. Photomicrograph of the smooth megascleres and spined gemmoscleres of Eunapius fragilis. 350X.

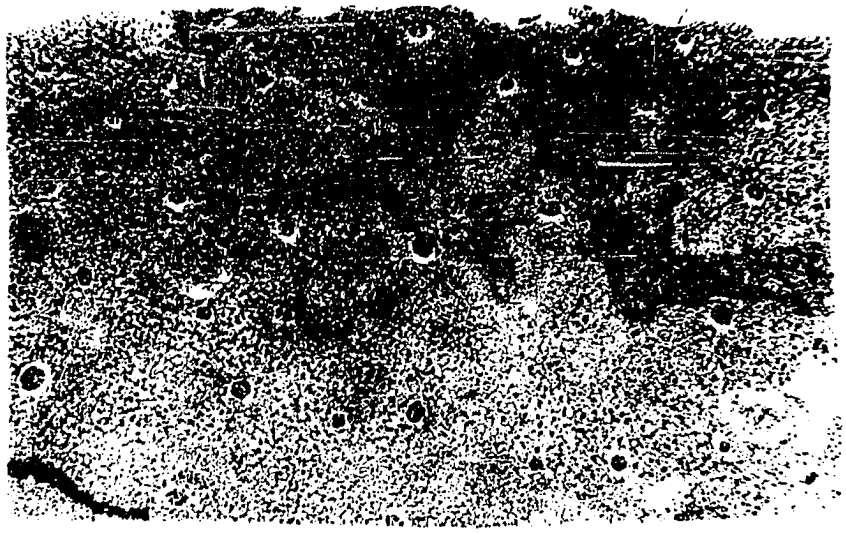


Figure 16

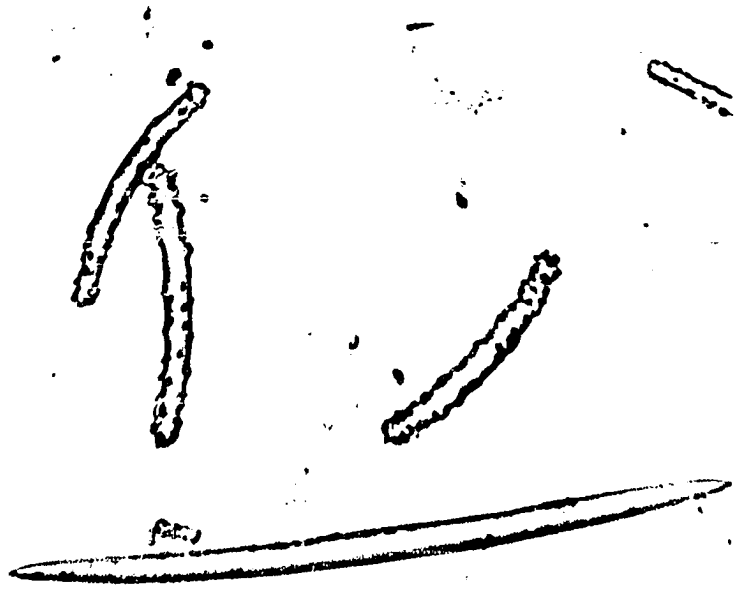


Figure 17

Figure 18. Photomicrograph of a megasclere and a gemmoscleres of Eunapius mackayi. 350X.

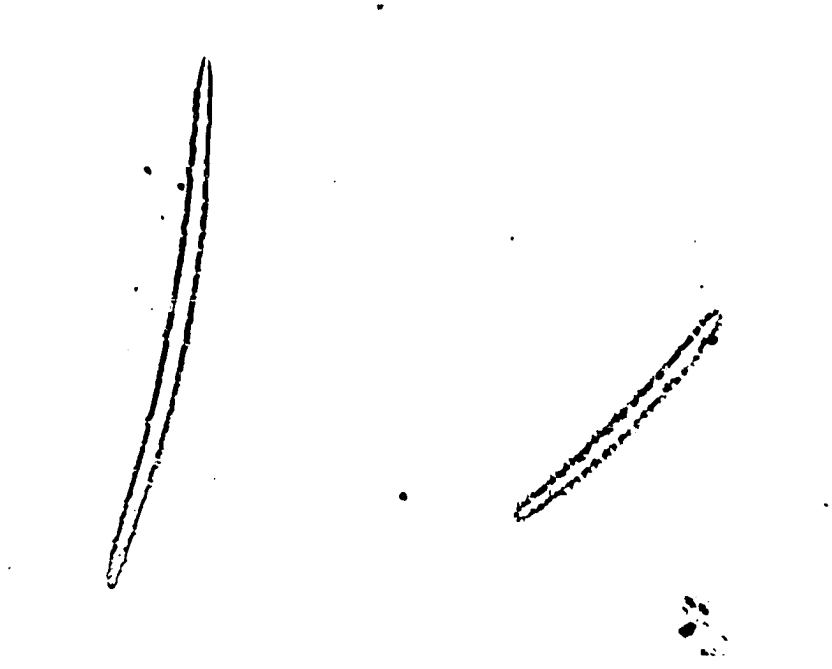


Figure 18

Figures 19-27. Photomicrographs of gemmoscleres of *Trochospongilla pennsylvanica*, *T. horrida* intermediates. 750X.

Figure 19

Figure 20

Figure 21

Figure 22

Figure 23

Figure 24

Figure 25

Figure 26

Figure 27

Figure 28. Photomicrograph of megascleres and birotulate gemmoscleres of Trochospongilla pennsylvanica. 350X.

Figure 29. Photograph of the surface of a colony of Trochospongilla leidyi; Natural size.

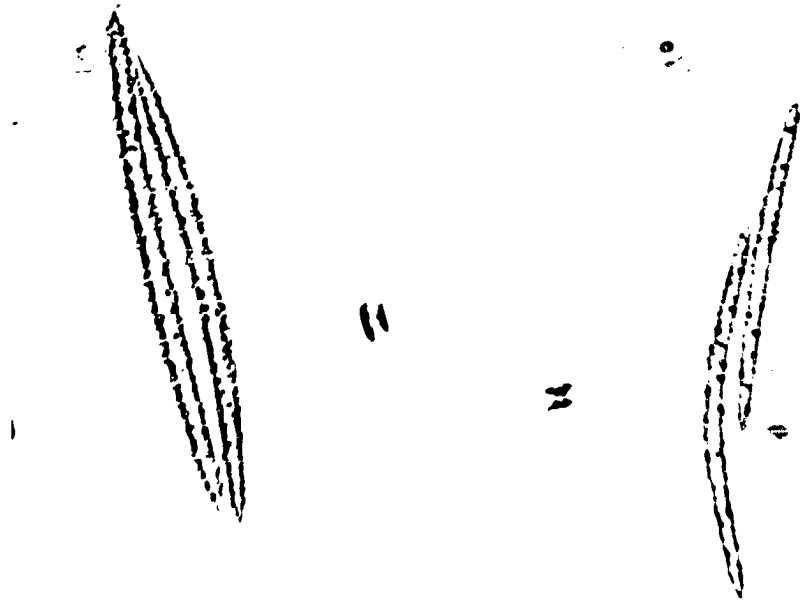


Figure 28

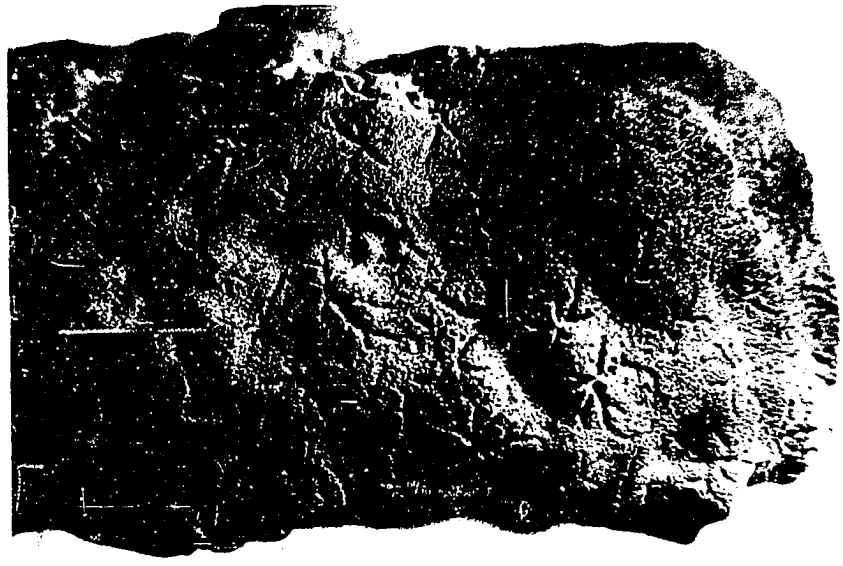


Figure 29

Figure 30. Photomicrograph of a megasclere and birotulate gemmoscleres of Trochospongilla leidyi. 750X.

Figure 31. Photomicrograph of large and small gemmoscleres of Anheteromeyenia ryderi. 750X.

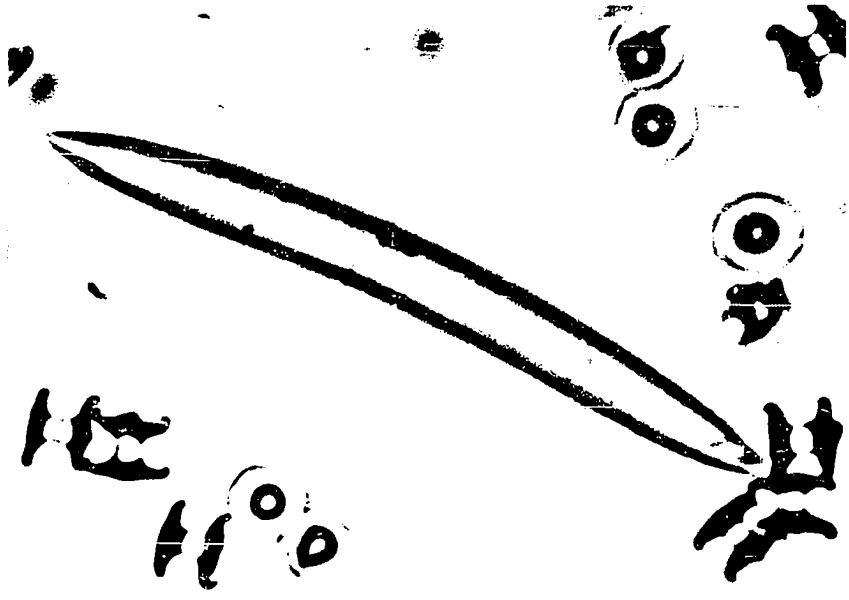


Figure 30

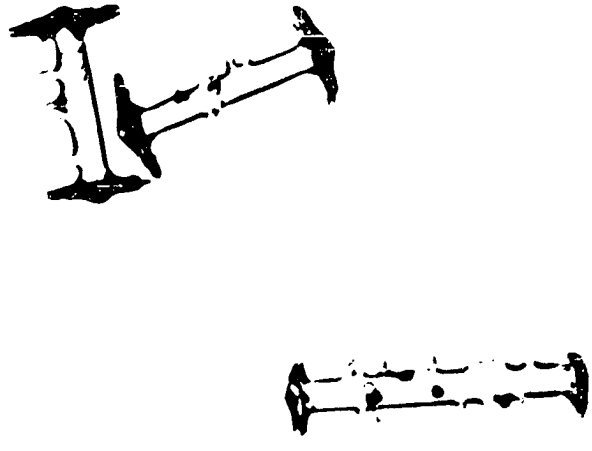


Figure 31

Figure 32. Photomicrograph of gemmoscleres of Anheteromeyenia ryderi from Evans Creek, St. Tammany Parish, 750X.

Figure 33. Photomicrograph of gemmoscleres of Anheteromeyenia ryderi from Carson Lake, Beauregard Parish, 750X.

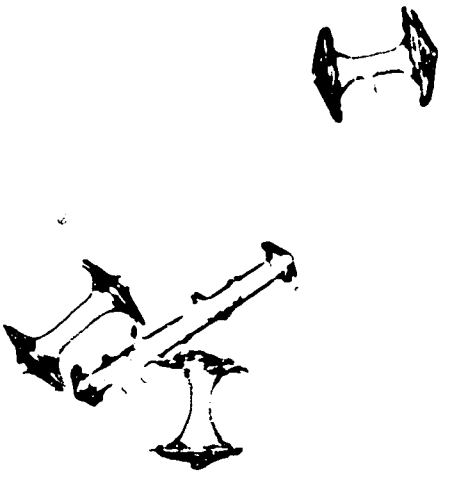


Figure 32

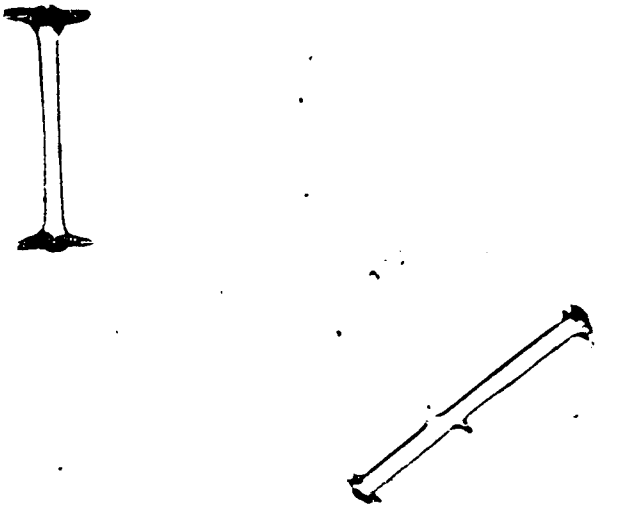


Figure 33

Figure 34. Photomicrograph of gemmoscleres of Anheteromeyenia ryderi from habitats of the Mississippi River floodplain, 750X.

Figure 35. Photomicrograph of gemmoscleres of Anheteromeyenia conigera (Old, 1931). 750X.

Figure 34

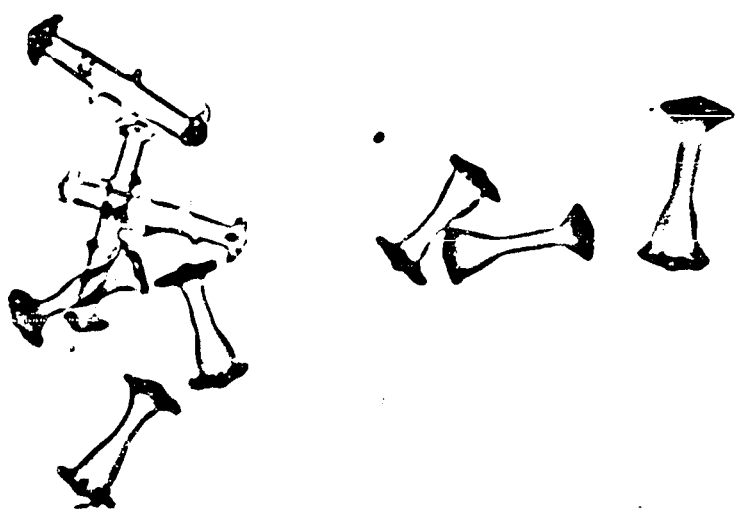


Figure 35

Figure 36. Phot micrograph of large gemmosclere of Anheteromeyenia argyrosperma. 750X.

Figure 37. Photomicrograph of small gemmosclere of Anheteromeyenia argyrosperma. 750X.

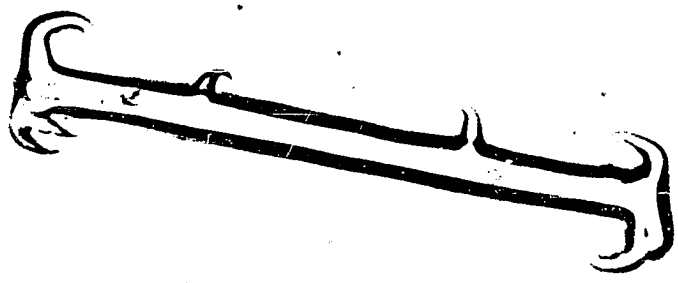


Figure 36

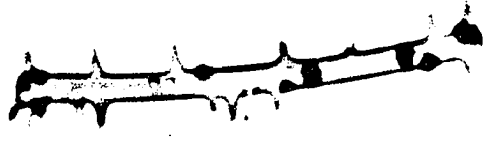


Figure 37

Figure 38. Photomicrograph of regular gemmoscleres of Radiospongilla crateriformis. 750X.

Figure 39. Photomicrograph of irregular gemmoscleres of Radiospongilla crateriformis. 750X.

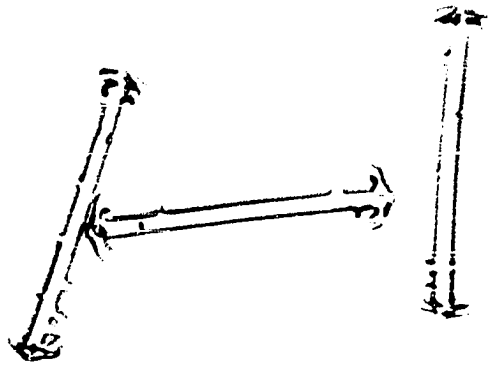


Figure 38

Figure 39

Figure 40. Photomicrograph of megascleres and microscleres of Heteromeyenia baileyi. 350X.

Figure 41. Photomicrograph of large and small gemmoscleres of Heteromeyenia baileyi. 750X.

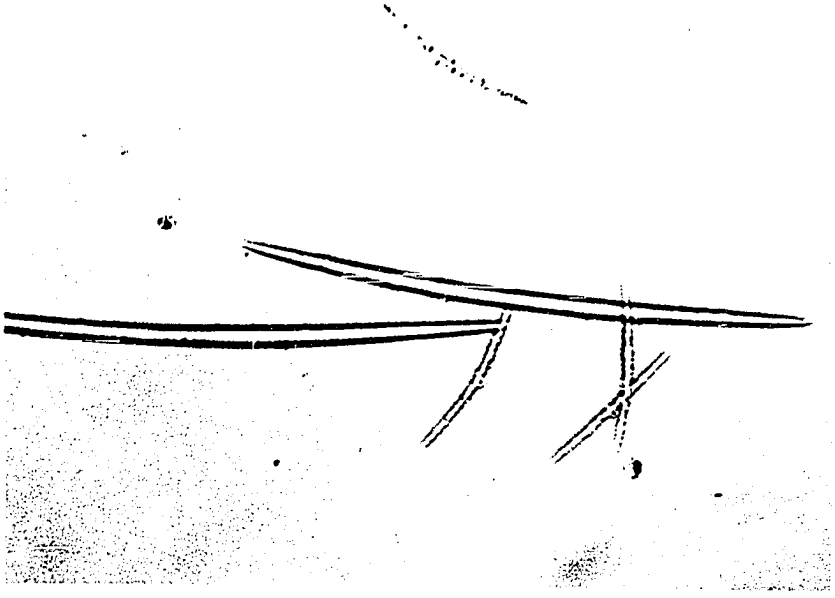


Figure 40

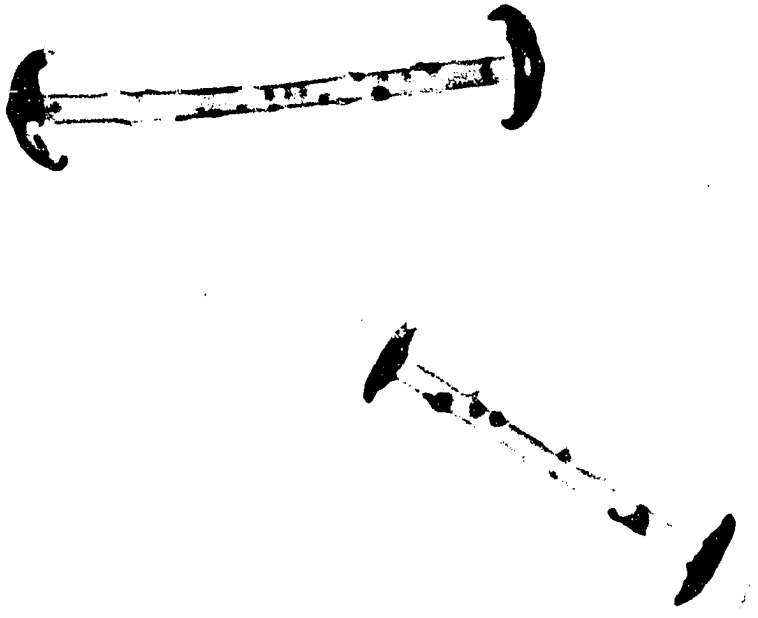


Figure 41

Figure 42. Photomicrograph of a microsclere of Dosilia radiospiculata. 750X.

Figure 43. Photomicrograph of a gemmosclere rotule of Dosilia heterogena. 750X.

Figure 42

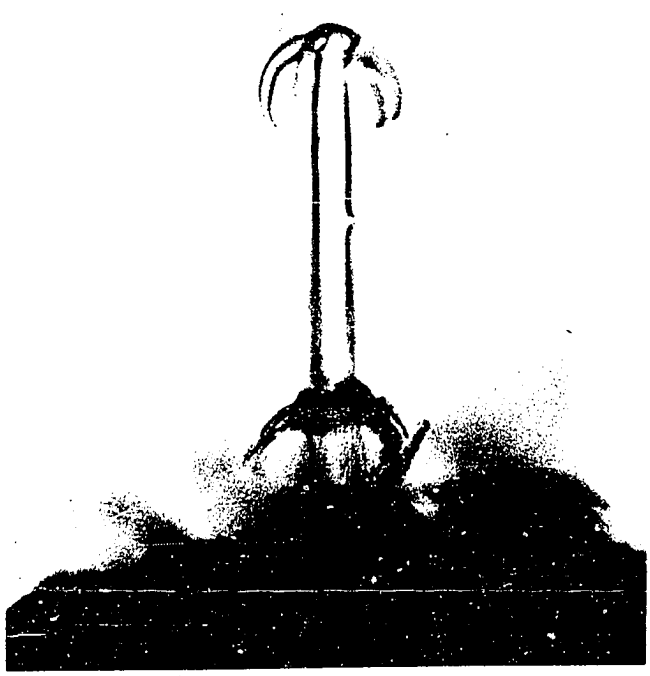


Figure 43

Figure 44. Photomicrograph of a gemmosclere rotule of Dosilia radiospiculata. 750X.

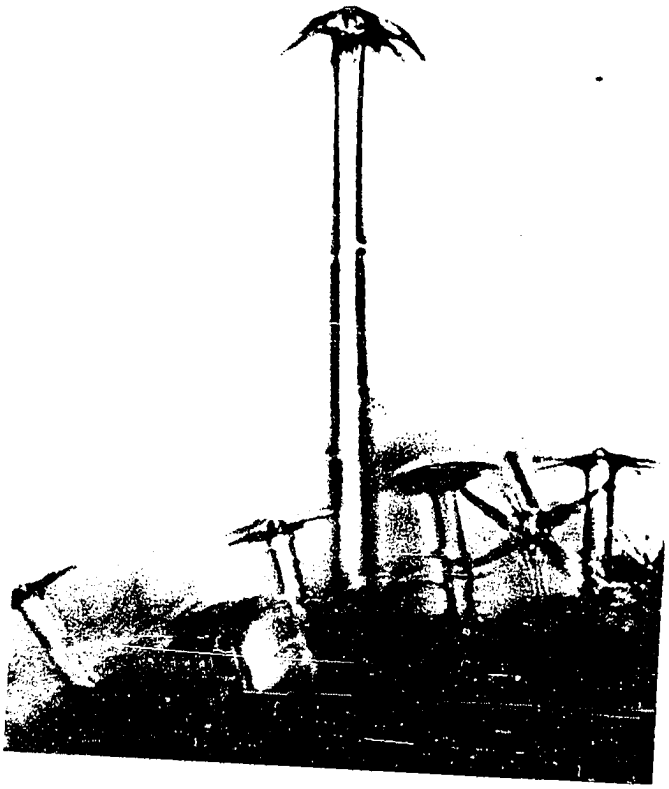


Figure 44

Map 1

Spongilla lacustris

Map 2

Ephydatia fluviatilis

Map 3

Eunapius fragilis

Map 4

Trochospongilla horrida

Map 5

Trochospongilla pennsylvanica

Map 6

Trochospongilla pennsylvanica, T. horrida intermediates

Map 7

Trochospongilla leidyi

Map 8

Anheteromeyenia ryderi

Map 9

Anheteromeyenia argyrosperma

Map 10

Radiospongilla crateriformis

Map 11

Heteromeyenia baileyi

Appendix

Distributional Data

Spongilla lacustris

Beauregard Parish: Hickory Creek at La. Hwy 12, November 18, 1966.

Calcasieu Parish: Lake Charles, Lake Charles, La., May 3, 1968.

DeSoto Parish: Clear Lake at La. Hwy 509, June 9, 1966.

Jefferson Parish: Lake Pontchartrain Causeway near shore, October 2, 1964.

Orleans Parish: New Orleans seawall near Orleans Street Drainage Canal, October 15, 1960; Chef Menteur Pass at US Hwy 90, February 12, 1964; Lake Catherine S E shoreline, August 7, 1964; Marsh Canal off US Hwy 11 5 mi S of Lake Pontchartrain, December 21, 1965.

Ouachita Parish: Chenier Lake at dam site, August 9, 1966.

St. Bernard Parish: Lake Borgne W of Chef Menteur Pass, September 20, 1951.

St. Charles Parish: Power line pilings near Bonnet Carre Spillway in Lake Pontchartrain, August 24, 1964.

St. Helena Parish: Stream at La. Hwy 37 N of junction with La. Hwy 449, April 19, 1968.

St. Tammany Parish: W tributary of Bayou Lacombe near Florenville, October 17, 1958; Tallisheek Creek at La. Hwy 41, July 2, 1964; Bushy Branch at La. Hwy 41, July

2, 1964; Beason Branch of Bogue Falaya River at La. Hwy 40, July 8, 1964; Tchefuncte River at US Hwy 190, August 1, 1964; Abita Creek at La. Hwy 435, July 1, 1964; Abita River at La. Hwy 435, July 1, 1964; Swampy stream at La. Hwy 1088, 1.2 mi S of junction with La. Hwy 36, January 21, 1965; Abita Creek 0.3 mi off La. Hwy 435 and 2.5 mi E of Abita Springs, La.; Lake Pontchartrain near causeway, June 29, 1964; N Shore at US Hwy 11, July 20, 1964; Tchefuncte River near Lake Pontchartrain, August 27, 1964; Tchefuncte River 0.5 mi S of Madisonville, La., August 16, 1968; Lake Pontchartrain E of Tchefuncte River, August 27, 1964.

Tangipahoa Parish: South Pass Manchac at US Hwy 51, August 12, 1964.

Vernon Parish: Vernon Lake lakeshore off dirt road E of US Hwy 171 and N of Anacoco Creek, August 17, 1968.

Winn Parish: Saline Bayou at Cloud Crossing Recreation Area, August 8, 1968.

Distributional Data

Ephydatia fluviatilis

Cameron Parish: Marsh Canal off La. Hwy 27, 4 mi S of the Intercoastal Waterway, May 3, 1968.

Jefferson Parish: Roadside slough off La. Hwy 45, 2 mi N of Crown Point, La., November 28, 1964; Temporary pool between R. R. tracks, Waggaman, La., April 14, 1964; Denta Drainage Canal S of Crown Point, La. ; March 23, 1964.

Orleans Parish: Lake Pontchartrain 0.5 mi E of the Orleans Street Drainage Canal, October 15, 1960; New Orleans City Park Back Lagoons, March 23, 1964; Marsh Canal off US Hwy 11, 5 mi S of Lake Pontchartrain, December 21, 1965.

Plaquemines Parish: Delta Duck Pond near Delta Duck Oil Field, September 5, 1964.

Pointe Coupee Parish: Slough at the junction of La. Hwy 1 and US Hwy 190, May 12, 1968.

St. Charles Parish: Slough off the Louisiana and Arkansas R. R. tracks, 3.5 mi S of Good Hope, La., February 15, 1964.

St. Tammany Parish: Tchefuncte River and Lake Pontchartrain, April 6, 1968; Tchefuncte River near Fairview State Park camping area, September 14, 1968; Tchefuncte River, 0.5 mi S of Madisonville, August 16, 1968.

Tangipahoa Parish: Lake Maurepas N W of Jones Island, November 13, 1965; N shoreline of Pass Manchac at US Hwy 51, August 12, 1965.

Vermillion Parish: Marsh Canal off La. Hwy 82, 5 mi W of Pecan Island, La., May 2, 1968.

Distributional Data

Eunapius fragilis

Assumption Parish: Cypress swamp off La. Hwy 70 just N of Little Bayou Pierre Part, June 28, 1968; Bayou Pierre Part at Pierre Part, La., June 28, 1968.

Avoyelles Parish: Old River at Marksville, La., July 14, 1968; Bayou de Glaises off La. Hwy 451, 6 mi E of Bordelonville, La., July 14, 1968.

Caddo Parish: Caddo Lake at N Shore at La. Hwy 1 Bridge, June 9, 1966; Wallace Lake N Shore near dam site, June 8, 1966; Roadside Slough off La. Hwy 1, 1.8 mi N of Red River Parish line; Cross Lake off Eastern N Lake Shore Drive, August 17, 1968.

Bossier Parish: Ivan Lake at La. Hwy 529, August 10, 1968.

Caldwell Parish: Lafourche Lake, June 21, 1966.

DeSoto Parish: Clear Lake at La. Hwy 509, June 9, 1966.

East Carroll Parish: Lake Providence at Cypress Point, July 20, 1968.

East Feliciana Parish: Beaver Dam at La. Hwy 10, 1 mi W of Amite River, September 3, 1968.

Evangeline Parish: Chicot Lake at La. Hwy 375, May 17, 1966; Chicot Lake, Chicot State Park Picnic Grounds, May 17, 1968.

Grant Parish: Lake Iatt near dam site, June 9, 1966; Natachie Lake at dam site, June 9, 1966.

Iberia Parish: Bayou Teche at La. Hwy 345, July 13, 1968.

Iberville Parish: Bayou Grosse Tete off La. Hwy 77, S of Rosedale, La., April 20, 1968; Bayou Maringouin, 6 mi S of Ramah, La., April 26, 1968.

Jefferson Parish: Slough off La. Hwy 45, 2 mi N of Crown Point, La., January 22, 1966.

Jefferson Davis Parish: Lake Author at Lake Author, La., July 13, 1968.

Lafourche Parish: Slough off La. Hwy 307, 5 mi N of intersection with Hwy 90, May 28, 1968; Bayou Boeuf just W of La. Hwy 307, June 8, 1968.

LaSalle Parish: Catahoula Lake off La. Hwy 28, June 20, 1966.

Livingston Parish: Tickfaw River at Lake Maurepas, July 25, 1966.

Madison Parish: Swamp off La. Hwy 80, 6 mi W of Mound, La., July 19, 1968; Chicago Mills Wildlife Management Area, Indian Lake, July 20, 1968.

Morehouse Parish: Lafourche Lake at La. Hwy 133, July 14, 1966.

Natchitoches Parish: Black Lake at Hwy 9, June 9, 1964.

Ouachita Parish: Chenier Lake at dam site, August 9, 1966.

Pointe Coupee Parish: Roadside Slough at intersections of La. Hwy 1 and US Hwy 190, May 12, 1968.

Red River Parish: Black Lake, 2.9 mi NE of US Hwy 84,71, August 26, 1966.

Richland Parish: Big Creek at La. Hwy 15, June 21, 1966; Lafourche Relief, 1 mi N of La. Hwy 15, June 22, 1966.

St. Charles Parish: Slough off Southern Pacific R. R. tracks, 3 mi S of Boutte, La., May 29, 1964.

St. Helena Parish: Slough off La. Hwy 10, 5 mi E of Greensburg, La., April 19, 1968.

St. Landry Parish: Canal S of US Hwy 190 and 5 mi W of Krotz Springs, La., March 4, 1967; Canal E of US Hwy 171 1 mi N of junction with US Hwy 190, May 12, 1968.

St. Martin Parish: Atchafalaya Swamp at W levee, 1 mi N of Henderson, La., May 2, 1968.

St. Mary Parish: Lake Palourde off La. Hwy 70 N of Morgan City, La., June 28, 1968.

St. Tammany Parish: Bayou Liberty at US Hwy 190, February 12, 1964; Swamp N of junction of US Hwy 90 and 190, April 28, 1964; Big Branch Bayou Lacombe at US Hwy 190, August 10, 1964; Tidal stream off Tchefuncte River, 0.5 mi S of Madisonville, La.; Bayou Chincuba at W causeway approach, August 5, 1968.

Tensas Parish: Lake Bruin at La. Hwy 606, July 11, 1967.

Vermillion Parish: Swamp at La. Hwy 82 N of Esther, La., May 2, 1968.

Vernon Parish: Slough off La. Hwy 10, E of US Hwy 171, August 17, 1968.

West Baton Rouge Parish: Slough off La Hwy 76, 1.4 mi E of La. Hwy 413, April 20, 1968.

Winn Parish: Saline Lake at Lyle's Camp, August 8, 1968.

Distributional Data

Trochospongilla horrida

Acadia Parish: Bayou Queue de Tortue at La. Hwy 91, July 13, 1968.

Assumption Parish: Bayou Pierre Part at Pierre Part La., June 28, 1968.

Avoyelles Parish: Bayou de Glaises off La. Hwy 451, 6 mi E of Bordelionville, La., July 14, 1968.

Bienville Parish: Kepler Lake near Greers Camp, August 12, 1966; Lake Bistineau at dam site, July 25, 1967.

Bossier Parish: Bayou Bodcau at La. Hwy 160, July 25, 1967; Lake Bistineau at dam site, July 25, 1967.

Caddo Parish: Cross Lake off S Lakeshore Drive, Shreveport, La., June 8, 1968; Caddo Lake, N shore at La. Hwy 1, June 9, 1966; Wallace Lake N shore near dam, June 8, 1966; Roadside slough off La. Hwy 1, 1.8 mi N of Red River Parish line, March 13, 1966; Black Bayou at Hwy 2 near dam, August 10, 1968.

Catahoula Parish: Stream at La. Hwy 8, Rhinehart, La., July 12, 1967; Wallace Lake at La. Hwy 124, July 12, 1966.

Concordia Parish: Levee barrow pit off La. Hwy 15, 1.3 mi S of Slocum, La., July 12, 1967.

East Carrol Parish, Slough off La. Hwy 598, 1 mi E of Shelburn, La., July 20, 1968.

East Feliciana Parish: Old channel of Comite River at La. Hwy 67, February 10, 1965.

Evangeline Parish: Chicot Lake, Chicot State Park camping area, July 13, 1967; Chicot Lake at La. Hwy 375, May 17, 1968; Chicot Lake, Chicot State Park picnic grounds, May 17, 1968.

Franklin Parish: Turkey Creek Lake at dam, July 21, 1968.

Iberia Parish: Bayou Teche at La. Hwy 345, July 13, 1968.

Iberville Parish: Bayou Gross Tete off La. Hwy 77 S of Rosedale, La., April 20, 1968; Bayou Maringouin, 6 mi S of Ramah, La., April 26, 1968.

Jackson Parish: Chattam Lake at dam, August 8, 1968; Caney Creek at La. Hwy 34, August 8, 1968.

Jefferson Parish: Kenta Drainage Canal S of Crown Point, La., April 23, 1964.

Jefferson Davis Parish: Lake Arthur at Lake Arthur, La., July 13, 1968.

Lafourche Parish: Drainage Canal W of US Hwy 190 and 5 mi N of Terrebonne Parish line, May 29, 1968; Bayou Boeuf W of La. Hwy 307, June 6, 1968.

Lincoln Parish: Cypress Creek at US Hwy 167, July 27, 1967.

Livingston Parish: Tickfaw River at Lake Maurepas, July 25, 1966.

Madison Parish: Indian Lake Chicago Mills Wildlife Management Area, July 20, 1968.

Natchitoches Parish: Black Lake at Hwy 9, August 9, 1968.

Ouachita Parish: Chenier Lake at dam, August 9, 1966.

Rapides Parish: Big Creek at La. Hwy 115, June 20, 1966.

Red River Parish: Grand Bayou at La. Hwy 784, August 9, 1968.

Richland Parish: Big Creek at La. Hwy 15, June 21, 1966.

St. James Parish: Canal off La. Hwy 20 N of Lafourche Parish line, May 28, 1968.

St. Martin Parish: Bayou Teche at Evangeline Longelellow St. Park, June 22, 1968.

St. Tammany Parish: Abita River at La. Hwy 435, July 1, 1964; Bayou Castine at US Hwy 190, August 8, 1964; Cane Bayou at US Hwy 190, August 8, 1964; Tchefuncte River at La. Hwy 21, August 9, 1964; Tidal stream off Tchefuncte River, 0.5 mi S of Madisonville, La., August 8, 1964; Bayou Du Zaire at La. Hwy 21, August 8, 1964; Bogue Falaya River at US Hwy 190, August 10, 1964; Big Branch of Bayou Lacombe at US Hwy 190, August 10, 1964; Bayou Lacombe at US 190, August 10, 1964; Bayou Liberty at US Hwy 190, August 10, 1964; Tchefuncte River, 0.5 mi S of Madisonville, La. August 16, 1968; Abita Creek before confluence with Abita River, September 29, 1968; Abita River after confluence with Abita Creek, September 29, 1968.

Tangipahoa Parish: Gravel Pit Lake off La. Hwy 16 E of Amite, La. and W of the Tangipahoa River, April 19, 1968.

Union Parish: Corney Bayou at La. Hwy 550, July 26, 1967.

Terrebonne Parish: Canal S of La. Hwy 20, 1 mi E of Gibson, La., June 28, 1968.

Washington Parish: Bogue Chitto River at La. Hwy 438,

August 13, 1968.

Webster Parish: Corney Lake at Spillway, July 25, 1967; Lake Bistineau at St. Park Camping Area, July 24, 1967.

West Feliciana Parish: Audubon Lake, W of US Hwy 61 and N of La. Hwy 965, June 30, 1968; Lake Rosemound near old bed of Gale's Creek, October 21, 1968.

Winn Parish: Range Creek at gravel road E of Saline Lake, August 8, 1968.

Distributional Data

Trochospongilla pennsylvanica

Beauregard Parish: Beckwith Creek at La. Hwy 27, May 16, 1968.

Bienville Parish: Small stream at La. Hwy 4 near Friendship, La., August 8, 1968.

Caldwell Parish: Lafourche Lake, June 21, 1966.

East Carrol Parish: Slough off La. Hwy 596, 3 mi N of Lake Providence, La., July 20, 1968.

East Feliciana Parish: Beaver pond at La. Hwy 10, 1 mi W of Amite River, September 3, 1968.

Grant Parish: Lake Iatt near dam site, June 9, 1966.

LaSalle Parish: Ditch off US Hwy 84, 1.5 mi S of Old River June 20, 1966.

Lincoln Parish: Slough off US Hwy 167 just S of junction with La. Hwy 151, July 27, 1967.

Madison Parish: Swamp off La. Hwy 80, 6 mi W of Mound, La., July 19, 1968.

St. Martin Parish: Atchafalaya Swamp at W levee 1 mi N of Henderson, La., May 2, 1968.

St. Tammany Parish: Abita Creek at La. Hwy 435, July 1, 1964; Bushy Branch Creek at La. Hwy 41, July 2, 1964; Small cypress swamp off La. Hwy 36 near Florenville, La., March 17, 1964; Swamp N of junction of US Hwy 90 and 190, April 28, 1964; Evans Creek at La. Hwy 41, July 1,

1964; Roadside ditch off gravel road, 4.5 mi N of Hwy 190 and W of Bayou Liberty, March 17, 1964; Bayou Chincuba at W Causeway approach, August 5, 1968.

Vernon Parish: Slough off La. Hwy 10 and E of US Hwy 171, August 17, 1968; Vernon Lake, Lakeshore off dirt road E of US Hwy 171 and N of Anacoco Creek, August 17, 1968.

Distributional Data

Trochospongilla pennsylvanica and *T. horrida* intermediates

Bossier Parish: Bayou Bodcau at La. Hwy 157, July 25, 1967.

DeSoto Parish: Clear Lake at La. Hwy 509, June 9, 1966.

East Baton Rouge Parish: Pond S of Port Hudson National Cemetery off La. Hwy 3113, June 30, 1968.

Jackson Parish: Slough off US Hwy 65, 2.4 mi N of La. Hwy 128, July 11, 1967.

Natchitoches Parish: Stream E of Goldonna at La. Hwy 156, July 27, 1967.

Ouchita Parish: Bayou de Siard off US Hwy 165 N of Monroe, La., July 14, 1966.

Tensas Parish: Slough off US Hwy 65, 2.4 mi N of La. Hwy 128, July 11, 1967.

Winn Parish: Dugdemona River at US Hwy 167, August 9, 1968; Slough off La. Hwy 126, 1 mi E of Natchitoches Parish line, August 8, 1968; Saline Bayou at Cloud Crossing Recreation Area, August 8, 1968.

Distributional Data

Trochospongilla leidyi

Acadia Parish: Bayou des Cannes, 4.3 mi SW of Enice, La., July 12, 1968; Bayou Queue de Fortue at La. Hwy 91, July 13, 1968.

Assumption Parish: Bayou Pierre Part at Pierre Part, La., June 28, 1968; Lake Palourde off La. Hwy 70 N of Morgan City, La., June 28, 1968.

Avoyelles Parish: Old River at Marksville, La., July 14, 1968.

Caddo Parish: Black Bayou at Hwy 2 near dam, August 10, 1968.

Concordia Parish: Levee barrow pit off La Hwy 15, 1.3 mi S of Slocum, La., July 12, 1967; Lake St. John off La. Hwy 569, 6 mi S of junction with La. Hwy 570, July 11, 1967.

East Carroll Parish: Lake Providence off La Hwy 596 NW of US Hwy 65, July 11, 1966.

Iberville Parish: Bayou Maringouin, 6 mi S of Ramah, La., April 4, 1968.

Jefferson Parish: Kenta Drainage Canal S of Crown Point, La., April 23, 1964.

Jefferson Davis Parish: Lake Author at Lake Author, La., July 13, 1968.

La fourche Parish: Bayou Boeuf just W of La. Hwy 307,

June 8, 1968.

Madison Parish: Chicago Mills Wildlife Management area, Indian Lake, July 20, 1968.

Natchitoches Parish: Black Lake at La Hwy 9, June 9, 1964; Cane River Lake off La Hwy 6, Natchitoches, La., September 5, 1968; Old River at Powhatan, La., September 5, 1968; Cane River Lake off La. Hwy 1223, S of Natchitoches, La., September 6, 1968.

Rapides Parish: Mill Pond at Zimmerman, La., September 6, 1968.

St. Charles Parish: Barrow pit N of Bonnet Carre Spillway and E of US Hwy 61, March 25, 1967.

St. James Parish: Canal off La Hwy 20 just N of Lafourche Parish line, May 28, 1968.

St. John the Baptist Parish: South Pass Manchac at US Hwy 51, August 12, 1964.

St. Landry Parish: Old Bayou Courtableau at US Hwy 190, August 27, 1968.

St. Martin Parish: Bayou Teche at Evangeline Longfellow St. Park, June 22, 1968.

St. Tammany Parish: Tchefuncte River near Lake Pontchartrain, August 27, 1964; Lake Pontchartrain, E of the Tchefuncte River, August 27, 1964; Lake Pontchartrain near the Lake Pontchartrain Causeway, June 29, 1964; Tchefuncte River, 0.5 mi S of Madisonville, La., August 16, 1968; Tchefuncte River, 4 mi upstream from Madisonville, La., September 14, 1968; Bayou Du Zaire at La. Hwy 22, August 25, 1968.

Tangipahoa Parish: South Pass Manchac at US Hwy 51, August 12, 1964.

Distributional Data

Anheteromeyenia ryderi

Allen Parish: Whiskey Chitto River at La. Hwy 26, November 20, 1966.

Ascension Parish: Swamp off Us Hwy 61, 2 mi SW Sorrento, La., February 8, 1965.

Beauregard Parish: Carson Lake off La. Hwy 27 S oi De Ridder, La., May 16, 1968; Beckwith Creek at La. Hwy 29, May 16, 1968; Slough off La. Hwy 111, 2 mi N of Merryville, La., May 16, 1968.

Iberville Parish: Atchafalaya Swamp at E levee, 5 mi S of Ramah, La., April 26, 1968.

Jefferson Parish: Slough off La. Hwy 45, 2 mi N of Crown Point, La., January 22, 1966.

Lafourche Parish: Slough off La. Hwy 307, 5 mi N of US Hwy 90, May 28, 1968.

Madison Parish: Swamp off La. Hwy 80, 6 mi W of Mound, La., July 19, 1968.

Natchitoches Parish: Slough off La. Hwy 118, 3 mi S of Red Dirt Game Management Area, May 16, 1968.

Pointe Coupee Parish: Slough near La. Hwy 1 and US Hwy 190, May 12, 1968.

Rapides Parish: Stream at La. Hwy 112, 3 mi E of Melder, La., March 11, 1966.

Sabine Parish: Bayou Toro at US Hwy 171, November 19, 1966.

St. Charles Parish: Slough off Southern Pacific R. R. tracks, 3 mi S of Boutte, La., May 29, 1964.

St. Helena Parish: Stream at La. Hwy 37 N of La. Hwy 449, April 19, 1968.

St. Martin Parish: Atchafalaya Swamp at W levee, 1 mi N of Henderson, La., May 2, 1968.

St. Tammany Parish: Roadside ditch off gravel road, 4.5 mi N of US Hwy 190 and W of Bayou Liberty, March 17, 1964; Swamp N of junction of US Hwy 90 and US 190, April 28, 1964; Evans Creek at La. Hwy 41, July 1, 1964; Bogue Falaya River at La. Hwy 40, May 26, 1964; Beason Creek at La. Hwy 40, July 8, 1964; Talisheek Creek at La. Hwy 41, July 2, 1964; Roadside Slough near lock 1 of Pearl River Navigation Canal, May 28, 1964; Small cypress Swamp off La. Hwy 36 near Florenville, La., March 17, 1964; Abita River after confluence with Abita Creek, September 29, 1968; Abita River at La. Hwy 435, July 1, 1964; Tchefuncte River at US Hwy 190, August 11, 1964.

Vermillion Parish: Swamp at La. Hwy 82 N of Esther, La., May 2, 1968.

Vernon Parish: Creek at US Hwy 171, N of Leesville, La., November 20, 1966.

Washington Parish: Pushepatapa Creek at La. Hwy 436, August 13, 1968.

West Baton Rouge Parish: Slough off La. Hwy 76, 1.4 mi E of La. Hwy 413, April 20, 1968.

West Carrol Parish: Slough off La. Hwy 17, 1 mi N of

Chickasas, La., July 20, 1968.

Winn Parish: Saline Bayou at Cloud Crossing Recreation Area, August 8, 1968.

Distributional Data

Anheteromeyenia argyrosperma

Bienville Parish: Small stream at La. Hwy 4 near Friendship, La., August 8, 1968.

Bossier Parish: Bayou Bodcau at La. Hwy 160, July 25, 1967; Ivan Lake at La. Hwy 529, August 10, 1968.

Caddo Parish: Cross Lake off S Lakeshore Drive, Shreveport, La., June 8, 1966; Caddo Lake N shore at La. Hwy 1, June 9, 1966.

Evangeline Parish: Chicot Lake, Chicot State Park camping area, July 13, 1967.

LaSalle Parish: Catahoula Lake off La. Hwy 28, June 20, 1968.

Natchitoches Parish: Black Lake at La. Hwy 9, August 9, 1968; Slough off La. Hwy 118, 3 mi S of Red Dirt Game Management Area, May 16, 1968.

Ouachita Parish: Chenier Lake at dam, August 9, 1966; Lafourche Relief, 1 mi N of La. Hwy 15, June 22, 1966.

St. Martin Parish: Atchafalaya Swamp at W levee, 1 mi N of Henderson, La., May 2, 1968.

St. Tammany Parish: Abita Creek, 0.3 mi off La. Hwy 435 and 2.5 mi E of Abita Springs, La., September 29, 1968; Abita River after confluence with Abita Creek, September 29, 1968.

Vernon Parish: Vernon Lake, lakeshore off dirt road

August 17, 1968.

Webster Parish: Caney Lake at spillway, July 25, 1967.

Winn Parish: Saline Lake at Lyle's Camp, August 8, 1968.

Distributional Data

Radiospongilla crateriformis

Acadia Parish: Bayou Queue de Tortue at La. Hwy 91, July 19, 1968.

Assumption Parish: Cypress swamp W of La. Hwy 70 just N of Little Bayou Pierre Part, June 28, 1968.

Avoyelles Parish: Bayou des Glaises, off La. Hwy 451, 6 mi E of Bordelonville, La., July 14, 1968.

Bienville Parish: Lake Bistineau at dam site at La. Hwy 154, July 25, 1968.

Bossier Parish: Lake Bistineau at dam, July 25, 1967; Bayou Bodcau at La. Hwy 157, July 25, 1967; Ivan Lake at La. Hwy 529, August 10, 1968.

Caddo Parish: Roadside Slough off La. Hwy 1, 1.8 mi N of Red River Parish line, March 13, 1966.

Caldwell Parish: Boef River at La. Hwy 561, June 21, 1966.

East Carroll Parish: Slough off La. Hwy 596, 3 mi N of Lake Providence, La., July 20, 1968; Slough off La. Hwy 598, 1 mi E of Shelburn, La., July 20, 1968.

Lafayette Parish: Lafayette, La., Girard Park Lake, August 27, 1968.

Lafourche Parish: Drainage canal W of US Hwy 90, 5 mi N of Terrebonne Parish line, May 29, 1968.

LaSalle Parish: Swamp off La. Hwy 84, 1.5 mi S of Old River, June 20, 1966; Catahoula Lake off La. Hwy 28, June 20, 1968.

Pointe Coupee Parish: Barrow pit near False River E of Bachelor, La., July 14, 1968.

Rapides Parish: Big Creek at La. Hwy 115, June 20, 1966.

St. Martin Parish: Atchafalaya Swamp at W levee, 1 mi N of Henderson, La., May 2, 1968.

St. Tammany Parish: Pool near Bogue Falaya River and US Hwy 190, August 10, 1964.

Big Branch Bayou Lacombe at US Hwy 190, August 10, 1968; Bayou Chincuba at La. Hwy 59, August 8, 1964; Bayou Chincuba at W Causeway approach, August 5, 1968; Abita Creek, 0.3 mi off La. Hwy 435 and 2.5 mi E of Abita Springs, La., September 29, 1968.

Union Parish: Corney Bayou at La. Hwy 550, July 26, 1967.

Terrebonne Parish: Canal S of La. Hwy 20, 1 mi E of Gibson, La., June 28, 1968; Slough off La. Hwy 20 just E of US Hwy 90, June 28, 1968.

West Carroll Parish: Small pond off La. Hwy 2 E of Morehouse Parish line, July 19, 1968.

West Feliciana Parish: Gravel pit lake, NE of Thompson Creek and US Hwy 61, June 30, 1968.

Distributional Data

Heteromeyenia baileyi

Assumption Parish: Bayou Corne at La. Hwy 70, June 28, 1968.

Caddo Parish: Wallace Lake N shore near dam, June 8, 1966; Roadside slough off La. Hwy 1, 1.8 mi N of Red River parish line, March 13, 1966.

Claiborne Parish: Corney Lake at Kisatchie National Forest camping area, July 25, 1967.

DeSoto Parish: Clear Lake at La. Hwy 509, June 9, 1966.

East Feliciana Parish: Beaver Dam at La. Hwy 10, September 3, 1968.

Iberville Parish: Atchafalaya Swamp at E levee, 5 mi S of Ramah, La., April 26, 1968.

Jefferson Parish: Temporary pool between R. R. tracks, Waggaman, La., April 14, 1964.

St. Landry Parish: Canal E of US Hwy 171 and 1 mi N of junction with US Hwy 190, May 12, 1968.

St. Martin Parish: Atchafalaya Swamp at W levee, 1 mi N of Henderson, La., May 2, 1968.

St. Tammany Parish: Bayou Du Zaire at La. Hwy 22, August 25, 1968; Bayou Chincuba at W Causeway approach, August 5, 1968.

Terrebonne Parish: Canal S of La. Hwy 20, 1 mi E of Gibson, La., June 28, 1968.

VITA

Michael Anthony Poirrier was born October 2, 1942, at Edgard, Louisiana. He graduated from De La Salle High School in New Orleans, Louisiana, in June of 1959. He attended Louisiana State University in New Orleans and received a Bachelor of Science degree in June of 1963. He entered the Graduate School of Louisiana State University, in June of 1963 and, in August of 1965, received the Master of Science degree in the Department of Zoology and Physiology, where he was an Instructor during the 1968-1969 session, and is now a candidate for the Doctor of Philosophy degree.

EXAMINATION AND THESIS REPORT

Candidate: Michael Anthony Poirrier

Major Field: Invertebrate Zoology

Title of Thesis: Louisiana Fresh-Water Sponges: Taxonomy, Ecology and Distribution

Approved:

W J Harman
Major Professor and Chairman

Max Goodrich
Dean of the Graduate School

EXAMINING COMMITTEE:

J H Roberts

James Avault Jr.

Clell B. Causey

H. Bruce Boudreaux

Date of Examination:

16 July 1969